

THE
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OF PRODUCTION
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JOURNAL



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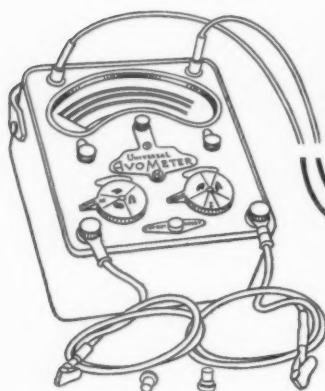
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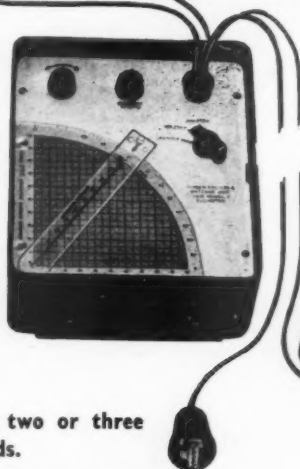
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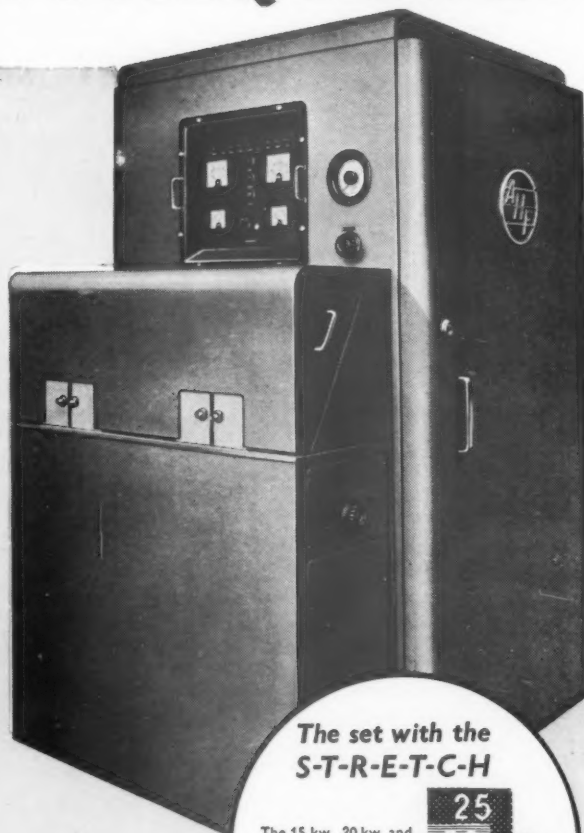
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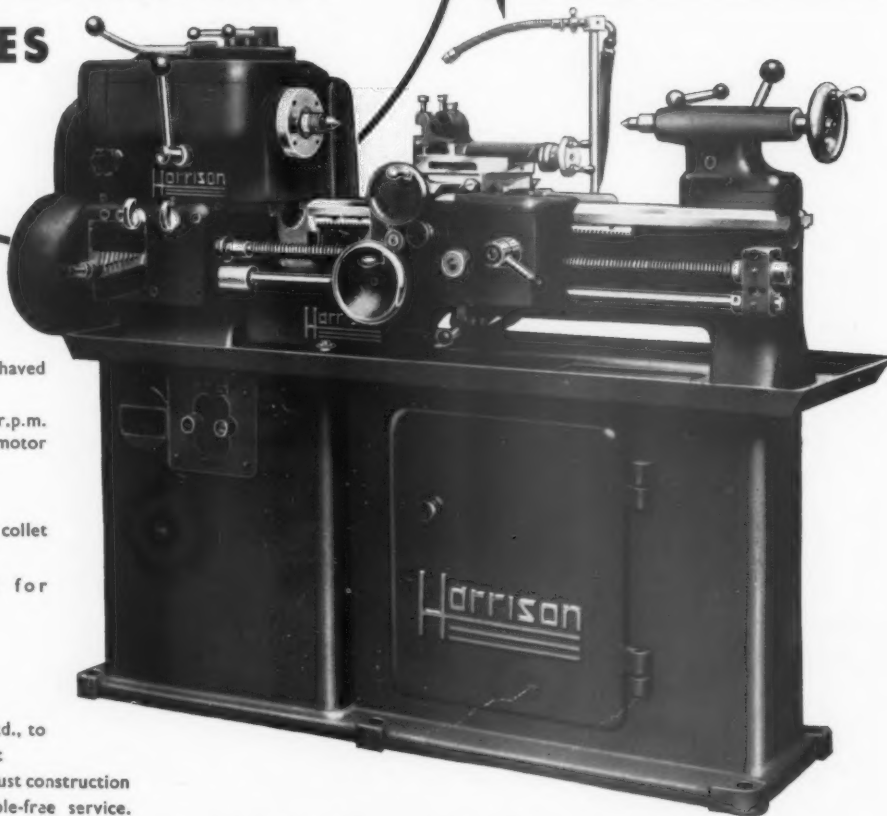
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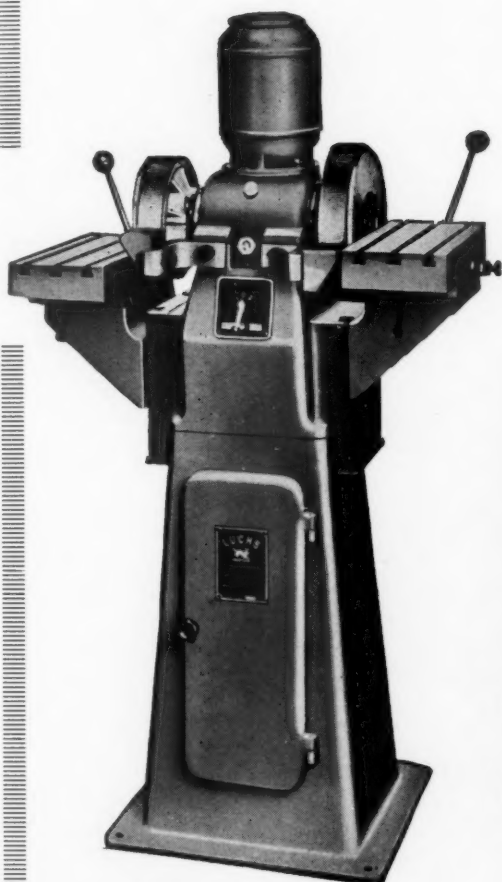
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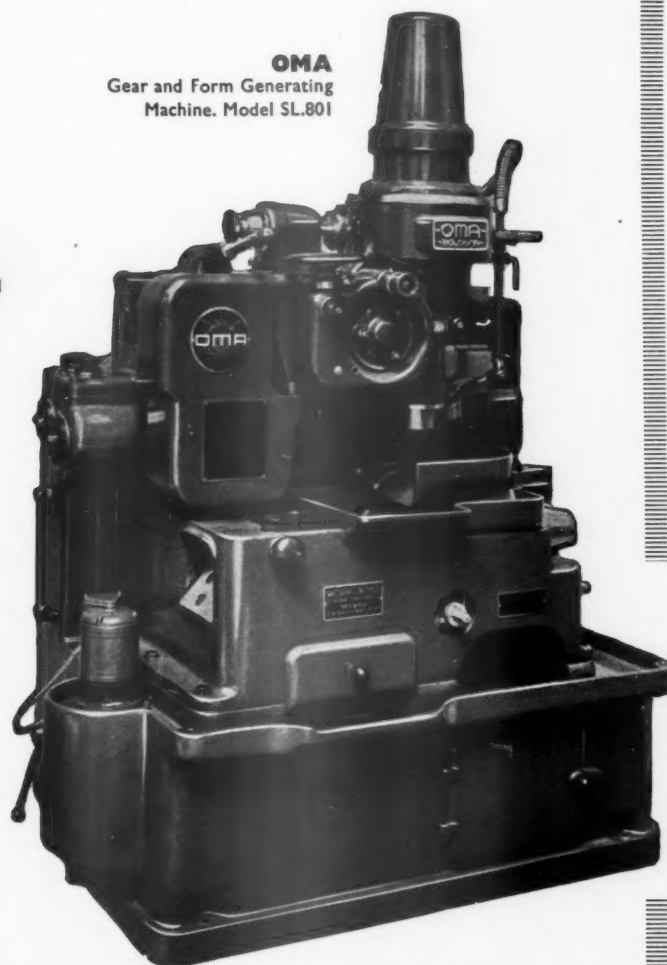
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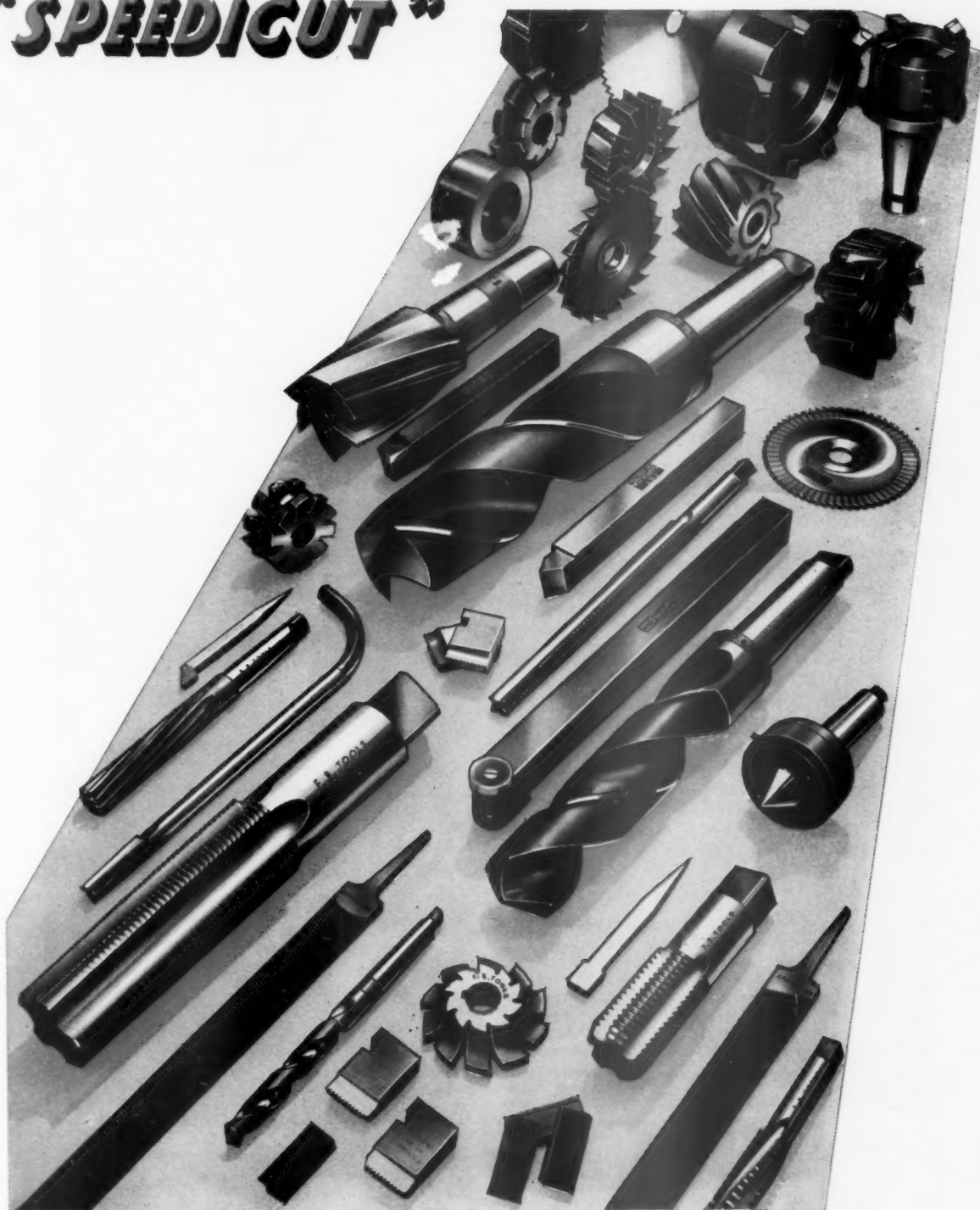
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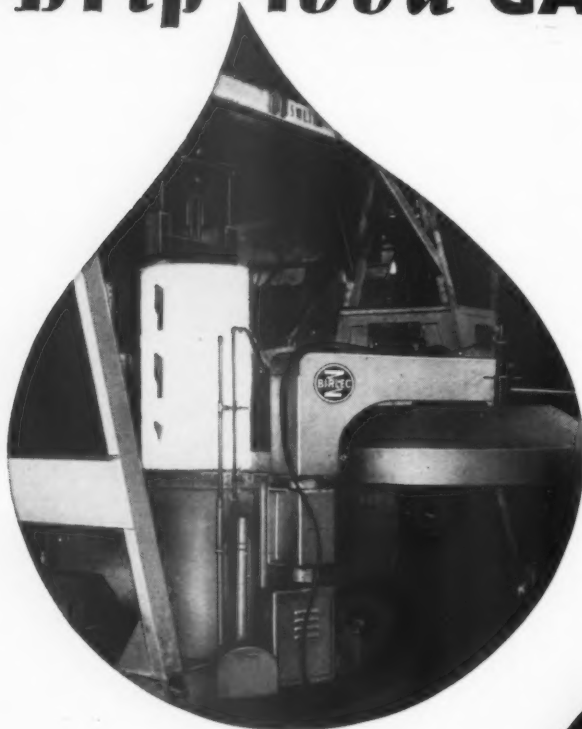
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Balance of Effort

by PROFESSOR ERWIN H. SCHELL,
School of Industrial Management,
Massachusetts Institute of Technology.

In the first contribution to a new series of leading articles dealing with "The Universals of Production", introduced last month by the Chairman of the Editorial Committee, an eminent American discusses the balance of effort in production over the next half-century.

SOMEONE has said that "freedom is based upon knowledge of necessity". While all such axioms have their limitations, there is a principle expressed here that may be useful as we attempt to discover those causative factors which explain the current emphasis upon production engineering and management in all industrial countries throughout the world.

In these remarks, which are prefatory to succeeding papers dealing with "The Universals of Production", I shall touch upon seven compulsions which appear to be well beyond the control of any single individual or group of men and which, in my opinion, are introducing necessities of a very real and practical nature—which we in the United States must recognise and to which we must bow.

The Necessity of Satisfying Public Expectations

Everywhere people hope for a better world for their children. This desire is, I am convinced, one of the greatest motivating forces affecting the behaviour of human beings. And, as our people view the products of industry, they not only hope but they fully expect that such outpourings from our mills and factories will each year become better, quicker and cheaper.

For reasons which are surely appropriate to our way of life in the United States, we are convinced of the value to us of what is called "free enterprise". To maintain free enterprise, it is necessitous that industry win and hold not only the acceptance but the loyal support of the public; and industry's surest approach here is through ever-better methods of management. Such a thought is close to that expressed at a banquet in 1935, at the time the International Management Congress met in London, when a member of the British Cabinet made a statement somewhat to this effect:

"We have good reason for welcoming this Congress to England, for we believe that good government, to be effective, should be long-term government; that long-term government demands a contented citizenry; and that in an industrial nation a contented citizenry is heavily dependent upon good industrial management."

It is a historical truism that after every War, pestilence, or famine, that state of the common people rises. With us in the United States, at least, there is the profound conviction that ever-advancing management is necessitous to national morale no less than to national prosperity.

The Necessity of Meeting Creative Competition

A second necessity springs from the presence of keen and indeed, severe, creative competition in American industry. With the public acclimated to the concept of constant improvement, industry has

found through repeated experiments that advances in good management which are reflected in higher quality, lower costs and prompter service yield almost immediate results in terms of increased competitive power. This discovery has led to the widespread development of organised efforts for the constant improvement of materials, products and prices. Again, we have found that such organised procedures materially accelerate such improvement.

It is obvious that the thousands of industrial research laboratories now in existence in the United States can only have flourished because of the practical benefits which have attended their efforts. At the present time, this interest in organised improvement is continuing to grow, to the point that it is now in some organisations becoming an important part of employee-training programmes no less than of supervisory education.

The Necessity of Furthering an Expanding Economy

A third necessity which we in the United States have come to recognise, is that prosperity and stability are in large measure dependent upon the presence and maintenance of an expanding economy. As time passes, we must either grow bigger and better or risk economic tragedy.

Thus far, the process which has served to assure such growth has been one in which the advent of improvement by better management and production engineering has brought larger and larger quantities of manufactured products within the purchasing power of increasing sectors of the public, and by so doing has added to the expansion of our industrial activities. Over and over again, industries first create new markets for new products and thereafter develop new products at a price within the buying ability of the potential customers. It is this acceptance of the responsibility of constant growth and improvement on the part of top management which marks one of the striking characteristics of our industrial evolution.

The Necessity of Collaborating in Innovative Military Development

The fact that necessity lies at the base of industry's collaboration with government in military development and output goes without saying. Yet in these activities industry finds much beside necessity to claim its interest.

For example, in certain areas military research and development are proceeding much more rapidly than in manufacturing because accomplishment here is not linked to commercial returns. Not infrequently the high developmental costs involved in new materials, new products or new methods, for the minimising of military casualties, properly exceeds the expenditure for similar developmental work which could be justified commercially.

While most of such activities are still veiled in secrecy, the progressive industries see further necessity in collaboration with them in the hope that ultimately the advanced findings of research and engineering development may be made available and practical for the national market.

I do not wish to give the impression that the government is in any sense wasteful of funds in the promoting of such activities. I am aware that there is very considerable competition among manufacturers for these government orders. Costs, therefore, continue to be of the first importance, although the ensuing price may be higher than would be justified for commercial production.

Needless to say, the military demands upon management and upon production engineering are as high as, if not higher than, those of commercial production in these areas. Added stress upon management comes about from the necessities inherent in rapid innovation and change which is characteristic of military material, and the unusual problems of collaboration and co-ordination between government and industry which are inherent.

The Necessity of Implementing Our International Interdependence

Slowly and with some hesitation, industrialists in the United States are accepting their growing responsibilities in areas of international import and export. Here a stark necessity, hitherto but dimly seen, is becoming clear. It is the necessity of active relationships with those countries which are friendly to our way of life, in view of the importance and inevitability of our interdependence.

If there is anything that we have learned from past Wars, it is that peace between friendly nations is a

flower which continues to bloom best from the nourishment of active industrial and cultural interchange. We are now beginning to accept the principle of interdependence, as well as the principle of active mutual relations, as bases for future national security and international amity.

The problem of relating the output of our production lines to the varied needs of other countries is one with which our industrialists have had all too little experience, and once again top management will inevitably turn to the Production Engineer for aid in meeting this difficulty.

The Necessity of Mastering Growing Complexity

Industry in the United States finds itself facing the necessity of dealing with ever-increasing complexity as its round of expansion, diversification and multiplication continues. This characteristic seems to be an inescapable concomitant of progress. Industrialists are still far from victory in their attempts to solve this problem, as the health hazards now surrounding the tasks of top management only too well attest. Industrialists are increasingly employing mathematics, statistics and a host of collateral devices and procedures in an attempt to meet this difficulty which threatens to engulf us. Here, once again, the Production Engineer and the management counsellor must accept highly important roles in the future, if we are to develop the engineering for discovering the inner simplicities upon which sound administrative policy must be built, in an ever more complicated world.

The Necessity of Increased Training in Industrial Technology and Management

It should be obvious that the task of the engineering mind in industrial improvement and development, as well as in management, is assuming gigantic proportions. No other conclusion can be reached than that there will be an increasing and accelerating demand for men trained in the art and science of management, no less than in the disciplines of technology.

Here is necessity built upon necessities. Efforts to deal with this issue promise to take two forms. On the one hand, there must be expansion in formalised training in these areas; on the other hand, there must be conservation in the use of such resources as are at hand. At the moment, the latter device seems most immediately promising. There is, to my mind, undoubtedly great current waste in the employment of trained brains within industry.

For example, group participation on the part of the engineering staff in managerial problem solving is in its infancy in this country. Again, the employment of highly trained minds in routine activities which can be readily mastered by a mind of less formalised preparation, is causing the dilution of such resources as are now available. This situation is the result of oversight rather than of purposeful exploitation of individuals.

In the United States, the enlargement of educational resources in the fields of management and technology is now swerving toward the rapid establishment of executive training programmes within industry, which supplement and enlarge upon the current experience and knowledge of operating executives. These programmes also call upon the Production Engineer and the industrial counsellor for advice in approaching the complicated techniques involved in managerial activities. Here the linkage between management and technology is intimate. An increasingly large number of industrial problems call for ultimate decision by a mind which is facile both in technological and in administrative areas.

Conclusion

The compulsions which spring from the maintenance of our system of free enterprise; from creative competition; from an expanding economy; from military developments; from the interdependence of free nations; from the growth of complexity; and from the scarcity of practitioners in the new art and science of industrial improvement, these are in my opinion the stern and implacable motivants, the necessities which dictate much that we do and much that we will continue to do. Knowledge of these necessities bases our industrial freedom.

In closing, may I pay tribute to those who selected the topic under which I submit this preface? Surely, there could be no more timely consideration among the membership of the Institution of Production Engineers than is this.

POTENTIALITIES OF SPHEROIDAL GRAPHITE CAST IRON FOR THE MACHINE TOOL AND GENERAL ENGINEERING INDUSTRIES

by A. B. EVEREST, Ph.D., F.I.M.

Presented to the Halifax Section of the Institution of Production Engineers, 11th March, 1953.



Dr. A. B. Everest

Dr. Everest has been associated with the technical development of cast iron for the past thirty years. He gained his Doctor's Degree at Birmingham University for work on aluminium in cast iron, and since 1928 has been engaged in the Development and Research Department of the Mond Nickel Company, on alloy and special cast iron, with particular reference to nickel.

Throughout his career, he has been closely associated with the Institute of British Foundrymen, having been President of the London Branch, and he is now Junior Vice-President of the Institute. He is also Vice-Chairman of the Technical Council, and has been awarded the Oliver Stubbs Gold Medal for his services to the Institute and foundry industry.

Dr. Everest has given a large number of Papers on alloy and special cast irons before metallurgists and engineers both at home and abroad. He also sits on B.S.I. and International Committees concerned with the Testing and Specification of Cast Iron.

S PHEROIDAL graphite cast iron or, as it is called for short "S.G. Iron", is the latest material to appear in the steady evolution of cast iron which has taken place during this century. The progress made in cast iron technology can be appreciated by taking tensile strength as an index, and studying the figures quoted for it in textbooks and specifications. At the beginning of the century, the accepted strength of cast iron as quoted in engineers' handbooks was only about 7 tons per square inch. The first British Standard for general grey iron castings was issued in 1928, when the minimum strength for the highest grade of casting was given as 11 tons per square inch (on the 1.2 inch diameter bar).

As further technical progress was made, new grades of iron were introduced, so that by 1938 the highest grade specified had a strength of 20 tons per square inch. This was raised to 23 tons per square inch in 1941, and in 1948 the current British Standard for general grey iron castings—B.S. 1452—quotes a minimum strength of 26 tons per square inch for the highest grade of casting generally available. S.G. iron was introduced commercially about five years ago, and already specifications have been accepted for it in many countries (though not yet in Great Britain), and these quote a minimum of 36 tons per square inch for S.G. iron as-cast, thus emphasising the extraordinary advances which have been made in recent years in the improvement of grey cast iron.

Although only five years old, S.G. iron is already in large scale production throughout the world, and is coming into use wherever improved cast iron is required. It often replaces steel, malleable cast iron and other materials, and has found application in almost every branch of engineering practice. In this Paper a general description is given of S.G. iron and its properties, and its application in general engineering, with special reference to the machine tool industry, is discussed.

Grey Cast Iron

In order to understand fully what is implied by S.G. iron, brief reference must be made to the metallurgical nature of cast iron. The principal difference between cast iron and steel lies in its carbon content. Grey cast iron generally contains about 3 per cent to 3.5 per cent of carbon, of which all but a small proportion, generally 0.4 to 0.6 per cent, separates as free carbon in the metal on cooling; thus cast iron can be considered in its simplest terms as a steel-like material containing about 2.5 to 3 per cent (by weight) of free graphite. In ordinary cast iron, this graphite is present in the form of thin flakes distributed throughout the metal. In considering the total quantity of graphite present, it must also be realised that due to its low specific gravity, the actual volume of graphite present in the casting is about



Fig. 1

Microstructure x 100 dia. showing graphite flakes in normal cast iron (unetched).

8 to 10 per cent of the whole. Fig. 1 shows a photomicrograph of ordinary cast iron. Close examination of the sections of the graphite flakes show that they have sharp edges. The matrix of the metal is known to be carbon steel, but the properties of the cast iron are determined predominantly by the quantity and form of the graphite flakes.

If plain and notched test pieces in carbon steel are subjected to impact test, it is found that the notch will reduce the impact strength to about 5 or 10 per cent of that of the unnotched specimen. The effect of sharp notches is well known to engineers and designers as "stress raisers", weakening and embrittling the metal. When cast iron is examined, under the microscope, it requires little imagination to appreciate that the whole of the metallic structure is interspersed with innumerable notches acting as stress raisers at the edge of each graphite flake, and this adequately explains the low strength and brittleness of grey cast iron.

Many attempts have been made in the past to prevent the graphite in cast iron from assuming the deleterious flake form. It is well known that when cast iron is produced under the conditions leading to malleable cast iron, then by causing the graphite to assume a nodular or lumpy form, not only is the strength of the material greatly improved, but the inherent brittleness of cast iron is eliminated and tough castings are produced. Until the development of S.G. iron, however, there was no established process for controlling the form of the graphite in the foundry so as to give high strength, tough metal as cast, free from the internal notch effect so predominant in ordinary cast iron.

S.G. Iron

Processes developed in Great Britain and the U.S.A in the last few years have now established the commercial possibility of producing iron castings directly in the foundry with the graphite modified from the flake to the spheroidal form, as shown in Fig. 2. These processes have proved of the greatest importance to engineers.

The advantage of all types of cast iron over steel is that the high carbon, derived in the first place from the pig iron made by the reduction of iron ore in the blast furnace, confers a high degree of castability on the metal. Grey cast iron, which in the early days of engineering was the basic material of construction, can readily be produced in the form of complicated castings and of all conceivable sizes from a fraction of an ounce to over 200 tons. In considering the adaptability of cast iron, it must be emphasised that, in addition to good castability into all the forms required by engineers, it offers many other advantages, such as good machining characteristics, the ability to take on a good finish, a much better wear resistance than many other metals, and also useful heat and corrosion resistance.

During the earlier part of this century, many attempts were made to improve the mechanical properties of cast iron, especially its strength and toughness. These attempts included the modification of metal mixtures, the use of ladle treatments of the molten iron, the addition of alloys and so on, but although some control could be exercised over the size and distribution of the graphite, it still remained in the flake form, and the castings, although of improved strength, had low toughness. It has only been in the last few years, with the development of S.G. iron, that grey iron castings have been made in the

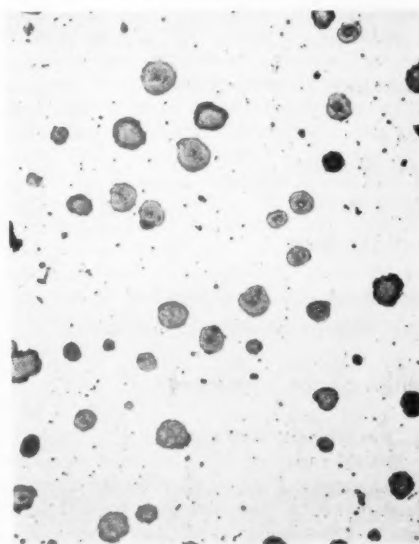


Fig. 2

Microstructure x 100 dia. showing spheroidal graphite in S.G. iron (unetched).

foundry with measurable elongation and a marked resistance to shock.

It should be mentioned that the process for modifying the graphite so that it assumes the spheroidal form can be applied to cast irons of many different types, and the improvements derived from modification of the graphite are available to engineers in a range of irons from the soft, fully annealed type, to heat-treated hard irons, and even to high alloy corrosion resistant irons.

In considering S.G. iron, properties are generally quoted for the two main types in most common use. These are S.G. iron, as directly cast in the foundry

into normal sections of castings and, secondly, the same material after being given a short annealing treatment at a temperature of about 900°C, followed by slow cooling to produce the maximum toughness and ductility in the metal.

Properties of S.G. Iron

There is an enormous literature on the general subject of S.G. iron—in fact, a recent Paper of the review type included a bibliography containing 354 references. The information available on the properties of S.G. iron was reviewed by the author in a paper given to the 4th International Mechanical

TABLE 1

PROPERTIES OF S.G. IRON AS CAST AND ANNEALED COMPARED WITH HIGH DUTY FLAKE GRAPHITE CAST IRON *

| PROPERTY | | High Duty Flake Graphite Cast Iron | S.G. IRON | |
|--|----------------------------------|--|--|--|
| | | | As Cast | Annealed |
| Ultimate Tensile Strength | t.s.i. kg/mm ² | 18—22 28—35 | 35—45 55—71 | 27—35 47—55 |
| Yield Point | t.s.i. kg/mm ² | — — | 25—35 39—55 | 20—25 31—39 |
| Elongation | per cent. | Nil | 1—5 | 10—25 |
| Transverse Rupture Stress | t.s.i. kg/mm ² | 38—42 60—66 | 55—65 87—102 | 55—60 87—94 |
| Compressive Strength | t.s.i. kg/mm ² | 60—65 94—102 | 65—80 102—126 | 45—58 76—91 |
| Compressive Yield Strength | t.s.i. kg/mm ² | — — | 32—40 50—63 | 24—32 38—50 |
| Elastic Modulus | lbs.s.i. kg/mm ² | 18 × 10 ⁶ 13.2 × 10 ³ | 25 × 10 ⁶ 17.6 × 10 ³ | 25 × 10 ⁶ 17.6 × 10 ³ |
| Brinell Hardness | | 210—240 | 230—280 | 140—180 |
| Impact Izod 10 mm sq., notched | ft. lbs. | 1 | 4 | 12 |
| Impact Charpy 10 mm sq., unnotched | kgm * | 0.3 | 1.1 | 10 |
| Endurance Limit, unnotched | t.s.i. ± kg/mm ² ± | 8.5 13.4 | 13—18 20—28 | 11—13 17.3—20 |
| Endurance Limit, notched 0.05" rad. | t.s.i. ± kg/mm ² ± | 8.0 12.6 | 9.5 15 | 8.2 13 |
| Endurance Ratio, unnotched | | 0.43 | 0.34—0.38 | 0.37 |
| Damping Capacity Ratio | | 4 | 2 | 1 |

* Kilogrammeters per cm² on 10 × 10 mm test piece 40 mm span.

Engineering Congress at Stockholm last June.¹ Table 1 is taken from the Stockholm Paper and summarises the mechanical properties available in S.G. iron as-cast and annealed, as compared with a high duty flake graphite cast iron.

The particular attention of engineers and designers is drawn to the following details in this table of properties:—

Strength The ultimate tensile strength of S.G. iron is approximately double that of the corresponding flake graphite type of iron. The material as-cast will, with normal compositions, have a strength around 40 tons per square inch. This, on annealing, falls to around 32 tons per square inch. The maximum strength figure available in grey cast iron is in the nickel-molybdenum alloy acicular cast iron which, with the graphite modified to the spheroidal form, has given strengths up to 60 tons per square inch. Similar figures have also been developed with S.G. iron on quenching and tempering heat treatment.

Yield Point The properties of S.G. iron in tension are different from those of flake graphite iron, in that the stress strain curve is of the form shown for steel, and the material demonstrates a true yield point, whereas in ordinary cast iron no true yield is observed. The yield strength of S.G. iron is high, exceeding that of malleable cast iron and equalling that of some types of cast steel.

Elastic Modulus The elastic modulus of S.G. iron lies between that of ordinary cast iron and steel. A figure of about 25 million lbs. has been determined repeatedly on S.G. iron, and this figure seems to be independent of the condition of the matrix of the metal.

Elongation It will be noted that S.G. iron shows a measurable elongation as-cast. Figures up to 10 per cent have been observed in the foundry, but a figure of 1—3 per cent is more usual for S.G. iron as-cast in this country. On annealing, the elongation of S.G. iron is generally in the range 10—20 per cent.

The ductility of S.G. iron has been demonstrated by many authors by showing bent and twisted test bars. Many of the illustrations show the similarity in this respect between S.G. iron and malleable cast iron, but engineers must not overlook the high elastic modulus and yield point of S.G. iron which, taken in conjunction with the ductility, show that although S.G. iron can be bent, it is at the same time a rigid material and resists deformation except under heavy load. This factor of rigidity is of considerable importance for precision machines, where stability and accuracy of dimensions must be maintained. In this respect the properties of S.G. iron are superior to those of malleable cast iron.

Toughness As would be expected from the modification of the graphite form, S.G. iron shows a high degree of toughness. Its resistance to impact is of the order of four times that of a flake graphite iron when the material is tested as-cast, and about 12 times when heat-treated S.G. iron is under test. The im-

proved toughness of S.G. iron is of great importance to engineers, and designers, and has led to many applications where it is replacing even cast steel for parts subject to shock.

Hardness S.G. iron has a dense structure and the hardness is generally about 30 to 50 points Brinell higher than the corresponding flake graphite iron. This feature is referred to in more detail below in relation to machinability and finish.

Production Economy

Enough has been said up to this point to indicate that S.G. iron has properties approaching those of steel. In fact, S.G. iron is in many cases successfully replacing parts made previously as steel castings and even, in some cases, as forgings. As mentioned above, the cast irons have a big advantage over steel in the fact that they can be readily cast into complex form. S.G. iron shares the good castability of the other cast irons. The castings not only have a good finish but, due to the castability of the metal, castings can be produced accurately, and the machining allowances necessary are very much less than required for steel castings. Even more striking is the economy possible when steel forgings, as required, for example, for crank-shafts, can be replaced by castings in S.G. iron. The reduction in the amount of metal which has to be removed in machining, represents substantial savings in machining time and costs.

Machinability

The machinability of S.G. iron is good. Various studies have been made both at home and abroad comparing the machinability of S.G. iron with that of alternative materials. A detailed study of this type was reported from the U.S.A.² In this work, it was established that for a given matrix structure, the machinability of S.G. iron is roughly the same as for flake graphite iron, but when compared at equivalent hardness levels or for similar strength levels, S.G. iron shows much better machinability than alternative materials, the advantage being quoted as 25 per cent higher cutting speeds under given conditions. At a given hardness level, the power consumption is higher for S.G. iron due to its greater toughness, but tool life is greater. S.G. iron may be machined wet or dry giving an excellent finish, and practical experience shows that the annealed type of S.G. iron can be machined at high speeds. In the annealed state, the iron generally gives long continuous turnings as for steel.

Experience by engineers who have now made wide use of S.G. iron confirms the theoretical conclusions given above. S.G. iron is reported generally to have good machining characteristics and to machine better than ordinary cast iron, giving an excellent finish. Its machining characteristics are far superior to those of steel, and in a recent example, it was reported that the finish which could be obtained on the machined

1. "The Engineering Properties and Applications of S.G. Iron" by A. B. Everest. "Engineer" 1952, volume 193, June 13 and 20, pages 794-795 and 838-840.

2. "High Machinability and Productivity of Ductile Iron", Kahlas, J.F., Zlatin, N., and Kropf, R.B. Metal Progress, 1951, LIX, 238-242.

teeth of a cut gear was better in S.G. iron than could be obtained under the best conditions with steel. This superior machinability is another important factor towards production economy when S.G. iron can replace cast or forged steel.

Wear Resistance

Factors which lead to the wear of iron castings are so complex that a detailed analysis of the wearing quality of S.G. iron is not yet available. Experience to date, however, indicates that for an equivalent hardness level, the wear resistance of S.G. iron is at least as good as that of flake graphite iron under well lubricated conditions. Some dry wear tests under very heavy load have indicated inferior results for S.G. iron as compared with the flake graphite type, this probably being due to the fact that the spheroidal form of graphite has different lubricating qualities as compared with flake graphite. Some tests on cylinder liners have given better results for S.G. iron than for plain iron, but it is difficult to draw a definite conclusion from these tests, since in other cases an opposite tendency has been indicated.

Under conditions encountered in gears, experience as referred to below seems to indicate that the wear resistance of S.G. iron as a gear material is excellent.

Heat-Treatable Types of S.G. Iron

As for other cast irons and steels, S.G. iron is capable of heat treatment to give a wide range of hardness—in fact, S.G. iron is available in a continuous series with hardness levels from about 140 up to 450 Brinell. High hardness can be developed by oil quenching and tempering, and for parts requiring extra strength and wear resistance, heat treatment is recommended. S.G. iron castings may similarly be flame or induction hardened to give high hardness on surfaces required to have extra wear resistance.

Welding

S.G. iron may readily be welded and, in fact, lends itself to all the known production techniques generally applied to high duty cast iron.

Applications of S.G. Iron with Special Reference to Machine Tools

On account of the properties it offers, S.G. iron has now become widely adopted in almost every branch of engineering. It has found special application in the agricultural industry, in engines of all types, in the textile industry, the automobile trade, railways, marine and for general plant and equipment. Its versatility is demonstrated by the fact that among outstanding applications are included light scaffold clamps with metal thickness less than $\frac{1}{4}$ " (Fig. 3), on the one hand, up to metal working rolls weighing up to 20 tons a piece, on the other (Fig. 4). Its range of usefulness is unlimited. For space considerations, attention is given here only to its applications and potentialities in the machine tool field.

In considering S.G. iron for machine tools, it must be recalled that while the mechanical properties of

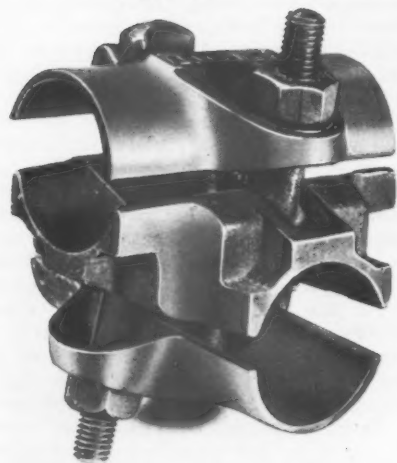


Fig. 3

S.G. iron scaffold clamp, demonstrating the use of the iron for light section castings, replacing steel and malleable cast iron.

(By courtesy of Pensotti, Italy.)

the iron have been improved to a surprising extent, as compared with the formerly available types of cast iron, there is in some directions a loss of the properties characteristic of grey cast iron. In ordinary cast iron, the form of graphite provides a cushioning effect within the metal which gives it its excellent damping capacity. With the more continuous matrix of S.G. iron and the more compact form of graphite, some of its damping capacity is lost, although in this respect S.G. iron is still markedly superior to steel. This is important, since although S.G. iron has already been adopted, especially in the U.S.A., for heavy parts of machine tools and for plant generally, it might prove less suitable for machine tool beds and frames where, on account of design, vibration might become troublesome.

On the other hand, there are many highly stressed structural components of machine tools in which steel is at present employed for strength reasons. In such cases, S.G. iron can offer advantages in providing strength approaching that of steel with better damping capacity. In heavy plant it has successful application for press frames (Fig. 5) and even for rolling mill housings.

Another direction in which S.G. iron has proved superior to all other alternative materials, is for large anvil blocks as used, for example, in stamps. These castings are massive. Fig. 6 shows a typical anvil block of a type which is made in weights up to 60 tons or more. In this case, steel, as previously used, distorted and gave a mushrooming effect at the top of the block. Cast iron, on the other hand, was not subject to this trouble, but in the grades previously available was not strong enough and was liable to failure by splitting. S.G. iron has been used extensively for this application, and has proved outstandingly successful. Use is, incidentally, also made of S.G. iron for the side frames of the stamps, and the

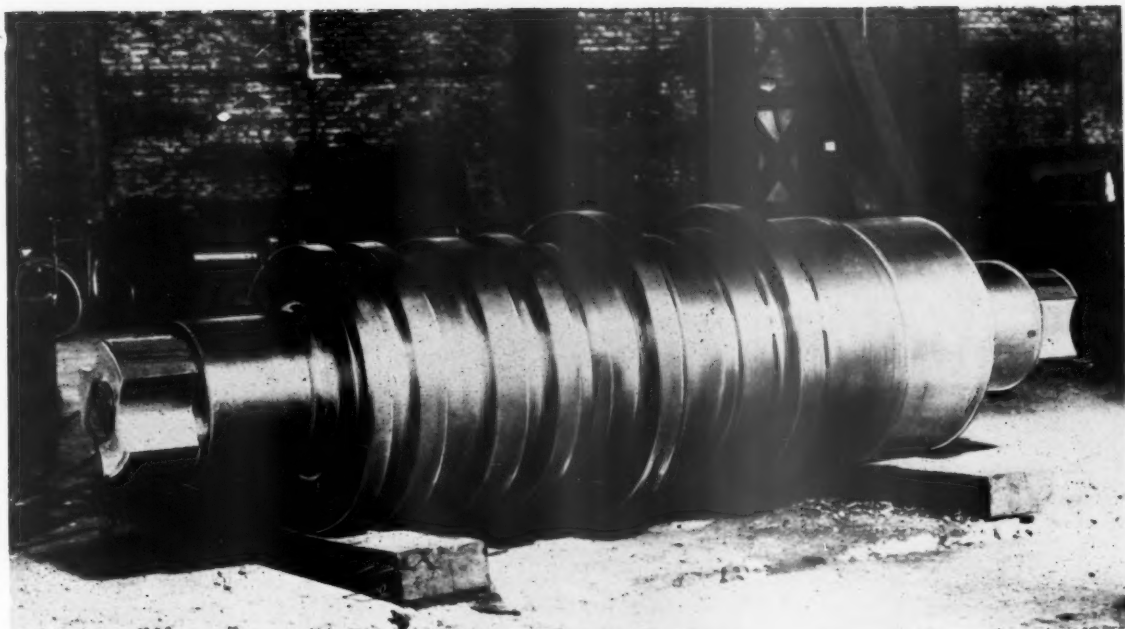


Fig. 4
S.G. iron section roll for continuous mill. Finished weight 12 tons, illustrating the use of the iron for heavy castings.
(By courtesy of Marichal Ketin, France.)

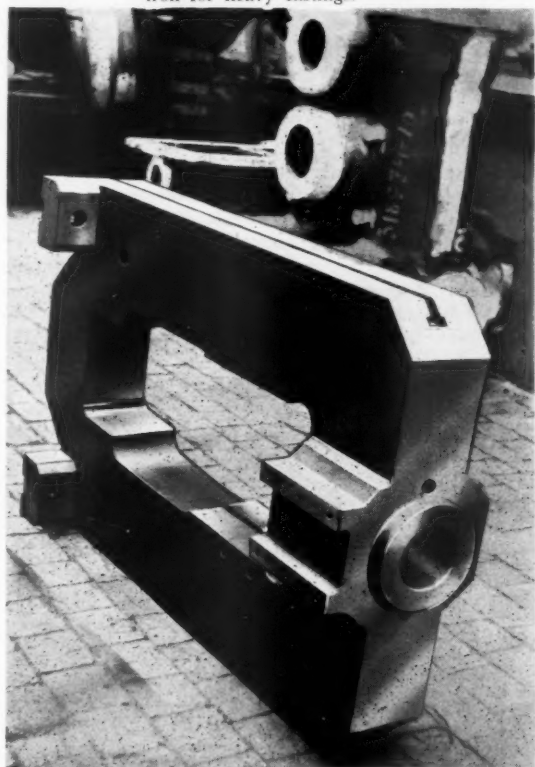


Fig. 5
S.G. iron press frame.
(By courtesy of Escher Wyss, Switzerland.)

guide-ways in the frames are sometimes flame-hardened.

Another application of special interest in connection with highly stressed parts is illustrated in Fig. 7 which shows a press die holder, replacing steel and cast iron. It is reported that one of these die holders, weighing 13 tons, survived without any damage whatsoever a mishap where steel sheet of twice the intended gauge was forced into the dies. The male and female dies were jammed solidly together and were only separated with great difficulty, but the die holder was able to withstand the stress and suffered no damage, whereas under these conditions, the ordinary die holders would have split.



Fig. 6
20 ton anvil block in S.G. iron.
(By courtesy of Chambersburg Engineering Inc., U.S.A.)



Fig. 7

S.G. iron press die holder.

(By courtesy of Fonderia Petri, Italy.)

S.G. iron has been used successfully for many moving parts on machine tools, for example, for saddles where, due to its greater strength, some lightening of section has been possible in the case of heavy machine tools. It has also been used extensively for tool holders of various types in automatic machines.

S.G. iron has replaced steel for heavy duty face plates, such as illustrated in Fig. 8, and has also proved outstandingly successful for chuck bodies.

A particular application of S.G. iron which, it is considered, emphasises the outstanding properties of this new material, is in connection with gears. Many producers of S.G. iron have turned their attention to the supply of gears with both cast and cut teeth for heavy duty service. For example, Figs. 9 and 10 show large gears with cast teeth destined for the drives of cement kilns and grinding mills, etc. Figs. 11 and 12 show gear components with machined teeth. As reported above, S.G. iron seems to lend itself admirably to gear cutting, and many of the papers describing its uses include examples of S.G. iron gears and racks.

Tests are in hand in this country at the present time to develop gear factors for S.G. iron. The results are not yet available, but a fairly complete review of S.G. iron as a gear material has been published before the American Gear Manufacturers Association recently.* In that Paper, successful results are reported in several cases where S.G. iron gears have been used to replace steel, and tests are reported to

develop the permissible loading of S.G. iron gears. The author concludes that S.G. iron gears can, under some conditions, carry the full loading previously considered for steel gears. Continuing, the author points out that it is not advocated that S.G. iron is necessarily going to replace steel as a gear material on a large scale, but it is clear that, due to its ready castability and other good characteristics, S.G. iron has a wide field of application for gearing, and the conclusion from several of the examples is that S.G.

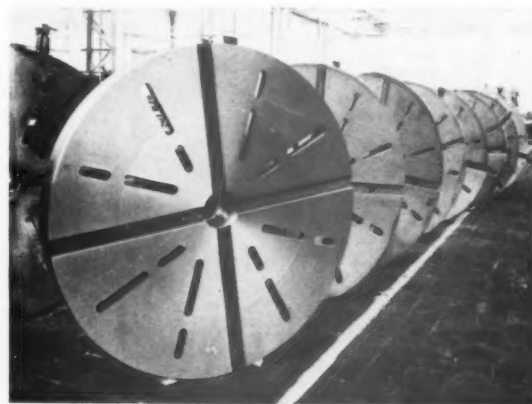


Fig. 8

Series of large S.G. iron face plates for lathes.

(By courtesy of Fonderies de la Campine, Belgium.)

* "Ductile Iron as a Gear Material", B. Hopper. 36th Annual Meeting of AGMA, June, 1952.

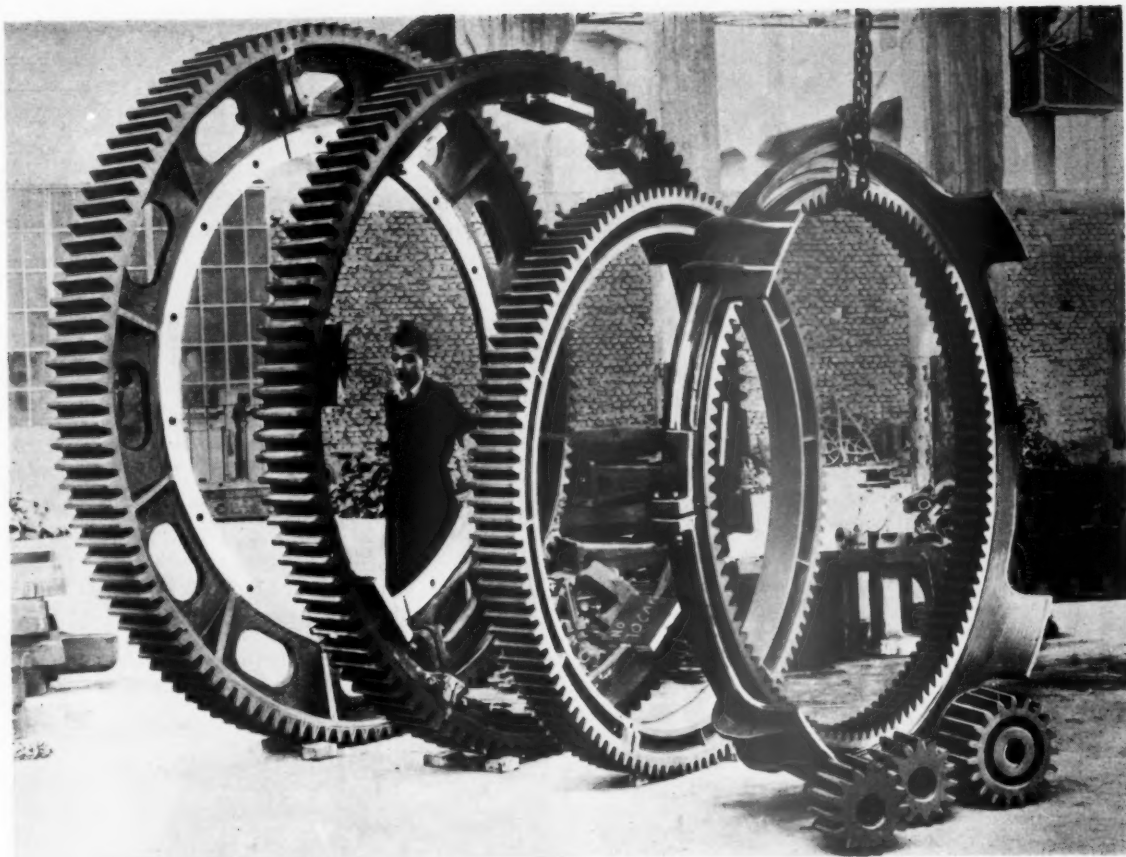


Fig. 9 (above)
Girth gear wheels and pinions in S.G. iron.
(By courtesy of Fonderia Tagliabue, Italy.)

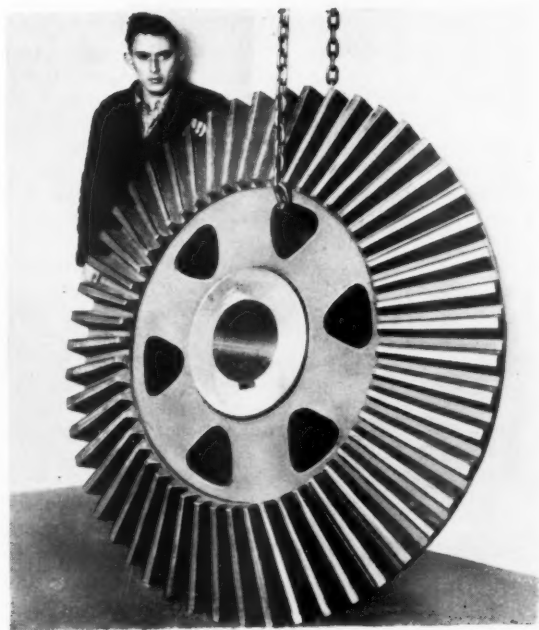


Fig. 10 (left)
S.G. iron bevel wheel, weighing $1\frac{1}{2}$ tons.
(By courtesy of Fonderia Tagliabue, Italy.)

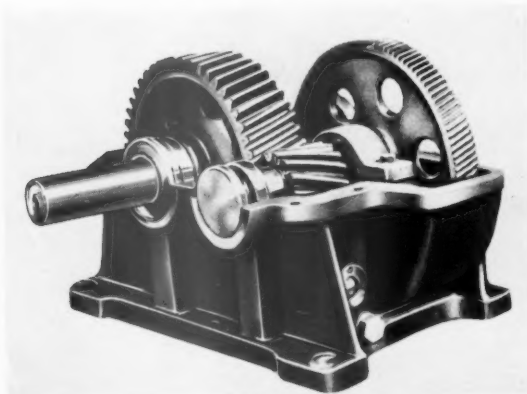


Fig. 11
Speed reducer. Gears in S.G. iron running with steel pinions.
(By courtesy of Fonderia Petri, Italy.)

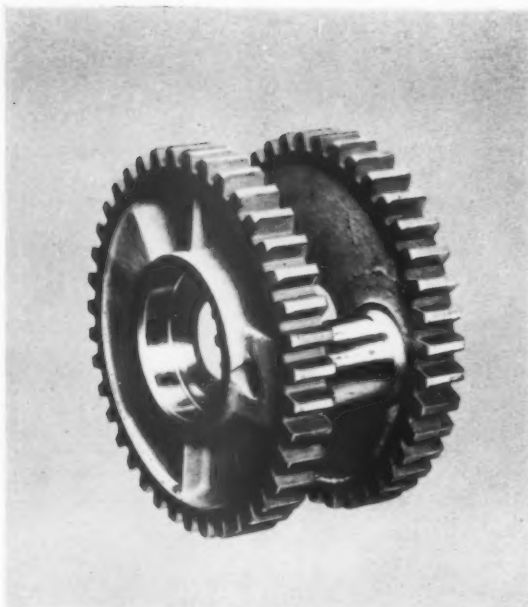


Fig. 12
S.G. iron gear crank for textile machine.
(By courtesy of Saurer, Switzerland.)

iron can, in general practice, safely be used at loadings up to 90 per cent of those for steel at 180 Brinell hardness, and up to 78 per cent of the loading at 300 Brinell hardness. In gears for mining and general plant, S.G. iron has been found to give the necessary toughness under shock loading, and has proved of special interest for large gears normally made in cast steel for kiln and grinding mill drives.

General Applications

S.G. iron, on account of its adaptability, is used for many details in general engineering and machine

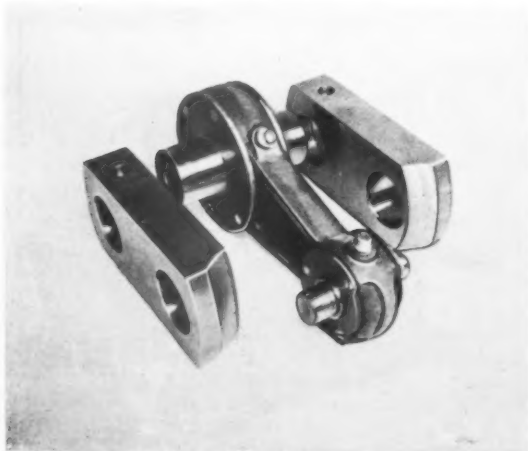


Fig. 13
S.G. iron crank webs and connecting rod for textile machine.
(By courtesy of S.K.F., Sweden.)

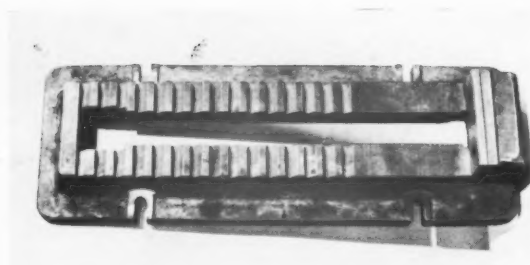


Fig. 14
Machine tool vice body in S.G. iron.
(By courtesy of Chavy, France.)

tools to replace steel and malleable cast iron. This applies particularly to the wide range of levers, cams, small connecting rods, handles and innumerable other items which enter into the construction of a finished machine tool (Figs. 13, 14 and 15). As indicated earlier, where required, working faces may be flame hardened, or the parts may be heat-treated to develop particular properties.

S.G. iron can be surface finished with much better success than ordinary flake graphite iron. It can be plated and tinned readily. This last item is of special interest, since S.G. iron is proving outstanding as a material for bearing shells, in many cases successfully

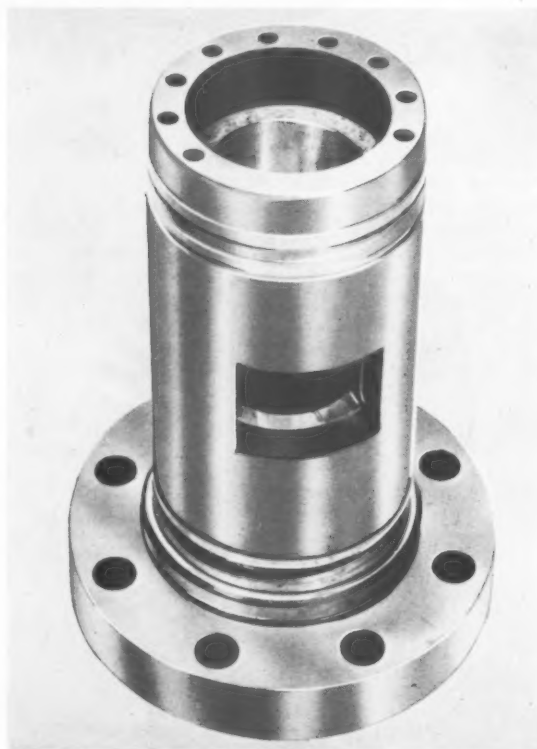


Fig. 15
S.G. iron barrel for plastic extrusion machine.
(By courtesy of Sheepbridge Engineering.)

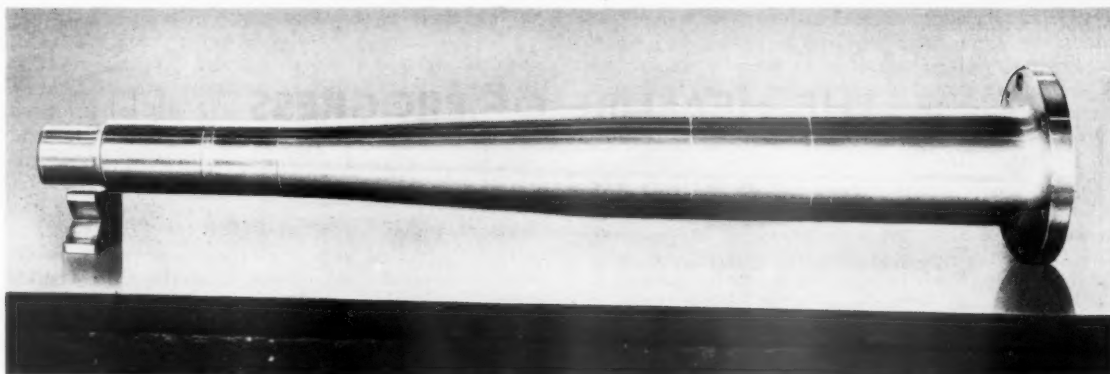


Fig. 16
S.G. iron motor generator shaft.
(By courtesy of Cooper Bessemer Corp., U.S.A.)

replacing bronze or steel.

S.G. iron has been used even for shafts on power equipment (Fig. 16). This opens up wide possibilities for its use for head-stock spindles which can be cast close to form, thus offering substantial production economies as compared with steel forgings.

Conclusion

S.G. iron is only five years old, but its wide

adaptability and the properties it offers, midway between cast iron and steel, has already led to its widespread use in every branch of engineering. Its application in machine tools is proceeding apace throughout the world, especially for small details in which it replaces steel or malleable cast iron. S.G. iron is available in a wide range of structures and properties, and its future, to quote an official report prepared for the U.S. Services, is very bright indeed.

The author acknowledges his indebtedness to the Directors of the Mond Nickel Company Limited for permission to publish this Paper.

WORK SIMPLIFICATION

Following the success of their course on Work Simplification early this year, the British Association for Commercial and Industrial Education, in collaboration with the Roffey Park Institute and the National Institute of Industrial Psychology, have arranged a further course on the same subject, to take place at Roffey Park Training Centre, near Horsham, Sussex, from 26th to 30th October, 1953.

The course is designed to provide training officers, managers, supervisors and others concerned in industry and commerce with a general understanding of work simplification, and the subjects covered will include the scope and purpose of work simplification; fact-finding techniques; incentives to efficiency; the trade union's attitude to work simplification; obtaining worker co-operation; significance of method; introduction to time study techniques; and the development of economic working.

An important feature will be a practical exercise based on the actual works problem in a well-known pharmaceutical manufacturers, where members of the course will have an opportunity of applying the principles reviewed to an actual production problem.

Full particulars may be obtained from the Training Officer, Roffey Park Institute, Horsham, Sussex, (Telephone: Faygate 204.)

HARDNESS TESTING CONFERENCE

A Special Conference on "Hardness Testing of Steel" has been arranged by the Sheet and Strip Metal Users Technical Association, and will be held

in the Memorial Hall, City Hall, Sheffield, on 14th/16th October, 1953.

The Conference, which includes an exhibition of hardness testing equipment, will be opened by the Master Cutler (Mr. Robert L. Walsh), and contributions are being made by many eminent foreign authorities.

Members who are interested in attending the Conference should contact the Hon. Secretary, Mr. A. McLeod, at the Association's offices, 49, Wellington Street, Strand, London, W.C.2.

CORROSION COURSE FOR ENGINEERS

It is announced by the Metallurgy Department of Battersea Polytechnic that a short course of lectures dealing with corrosion of metals will commence on 1st October, 1953. The subjects covered will include "Electro-chemical Principles of Corrosion"; "Choice of Metals for Particular Forms of Service"; "Protection by Metal Coatings"; "Corrosion Inhibitors"; "Cathodic Protection"; "Protection by Paints"; and "Temporary Protectives, Packing and Storage". The inclusive fee for the series is 25/-.

Further particulars may be obtained on application to the Secretary (Corrosion Course), Battersea Polytechnic, London, S.W.11.

ISSUE OF JOURNAL

Owing to the fact that output has to be adjusted to meet requirements, and in order to avoid carrying heavy stocks, it has been decided that the Journal will only be issued to new Members from the date they join the Institution.

THE MEASURE OF PROGRESS

by F. G. S. ENGLISH, M.I.Prod.E.

Presented to the Cornwall Section of the Institution, 26th March, 1953.



Mr. F. G. S. English

Mr. F. G. S. English, who is a Director of Powers-Samas Accounting Machines Limited and General Manager of the Production Division, has been with the Company for 28 years. A considerable proportion of this time has been spent in the various production departments and while in the Research and Engineering Drawing Office Mr. English played an important part in the design and development of Powers-Four equipment, the introduction of which brought punched card accounting within the range of an entirely new field of users.

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FOREWORD

While the ultimate object of this Paper is to establish a means for measuring progress in the improvement of productivity, its main purpose is to stimulate thought around a broad conception of the factors which can contribute to this progress.

Two specific problems are tackled—firstly, the difficulty in establishing a constant measure of output in spite of changes or variety in product and improvement in methods of manufacture, and secondly, the difficulty in establishing a constant measure of resources expended in spite of changing wage and salary levels.

It may prove helpful to readers to include in this foreword a summary of the proposals outlined in the Paper, as follows:

PRODUCTIVITY is a word that has achieved a popularity far outstripping a general understanding of its modern meaning. In a broad sense it can be taken as the qualification of industrial progress. This Paper is written around the broadest possible conceptions and aims at revealing the vast array of management functions which can affect productivity, finally pointing the way to a measure of progress. The study of productivity was the reason for a recent invasion of the North American continent. As compared with the reception given to those earlier invaders who sailed in the Mayflower, our contemporary invaders enjoyed a far more cordial

reception and, dare it be said, their discoveries were of far greater importance.

Process is measured in base hours—time normally taken.

Method improvement is measured whereby the reduction in base hours of process relative to a datum year is revealed in a method index figure.

Current base hours of process multiplied by the method index figure provides a constant measure of output, referred to as basic hours.

Finally, a measure of progress is established by relating basic hours of process to the expenditure of resources measured in cost adjusted to the levels prevailing in the datum year.

The Reports of the Anglo-American Council on Productivity, written around the investigation of 911 individuals comprising forty-seven industrial teams and nineteen specialist teams, cover such a broad field and contain such a wealth of information, that it is surprising that narrow views on the modern meaning of the word still persist—but they do.

With regard to these Reports, it is generally agreed that the British best is as good as, or may be better than, the U.S.A. best. One reason that we lag behind in general is that, in our insular way, we are slow

to copy the good in others and, just as vital, slow to reveal the good in ourselves.

There are still far too many industrial ostriches audibly drawing attention to their stupid contortions by muttering "it doesn't apply to us." It may well be that many of the small concerns which make up the greater proportion of British industry regard productivity as a quality to be confined to the larger and basic industries.

It may well be that some of the larger concerns consider they know all there is to be known on the subject, an attitude of mind which frequently leads to preaching without practising. All of us, small concerns and large, should have an open mind and approach the subject with a "charity begins at home" attitude.

Finally, in introducing this Paper, let me borrow a phrase and liken an attack on productivity to a military operation. The Intelligence Officers locate the objectives, the General directs the operation and the whole army carries out the attack. In industry the Intelligence Officers may well be the cost accountant and the production engineer, but the whole industrial team must, and I feel sure will, join wholeheartedly in the attack.

Definition

In any discussion, debate or committee consideration of such subjects as Industrial Administration, or Production Control, confusion frequently arises over the meaning of terms. We lack an established and universally accepted industrial terminology; witness the frequency with which writers on such subjects add a glossary of terms to their work. This problem was fully appreciated by the Organisation for European Co-operation when they formed a Productivity Group. Accordingly they published a terminology of productivity for use by the Group and, as pointed out in the introduction, issued it in the hope that it may make some contribution to the development of the studies on productivity statistics now being pursued in many European countries. However, even in this publication we find a leaning toward the narrow view, for it is laid down that productivity without qualification means productivity of labour. There is no clear definition of labour except to say that it is preferable to exclude sales, advertising and publicity. It is, however, pointed out that it can be influenced by the combined effect of a large number of inter-related factors such as the amount and quality of equipment employed, technical improvements, etc., etc.

It can only be hoped that designers, administrators, production engineers, accountants and inspectors are happy to be classified as "inter-related factors."

For the purpose of this Paper, the broad view is taken whereby the efficacy of all human industrial endeavour is qualified in terms of productivity. Let production describe the direct function of producing, efficiency qualify performance in each of the many functions contributing to production and let productivity qualify the total result.

There is no universal measure of productivity any more than there is a universal measure of production or human efficiency. A great deal of progress is necessary before such universal measurement can be contemplated. Indeed, a great deal must be accomplished before even comparisons within each type of industry become possible, and this should be the first objective.

In the absence of accepted standards, productivity can only be expressed as a ratio. It is the ratio of what we get for what we expend in getting it. It is a measure of the production of the things which are needed divided by a measure of the resources expended in producing them. Production of the things which are needed—this phrase is used deliberately, for in the final analysis consideration must be given to the efficacy and desirability of the products on which we expend national resources.

Reason

Before examining some of the difficulties attendant upon establishing a measure of progress, consideration should be given to the reason for embarking on this task, so that there is conviction that it is worth the effort.

The need for greater productivity is well established by clear Government statements illustrating its effect on internal economy and overseas balance of payments. It is recognised that our very existence may well depend on the ability to produce more.

It is known that those vital export markets depend on the lowering of prices and, therefore, costs. While more could be produced with a greater labour force or longer hours, it is necessary to face up to the fact that although the population is increasing, so is the average age. While costs could be reduced by two or three shift working, it is necessary to have regard for the general desire for a higher standard of living, not one reduced by the social upheaval attendant upon large scale shift work. There are some instances where longer hours have been proved to reduce production and increase costs.

It is easy to appreciate the advantages and lasting benefit to be derived from a steadily improving productivity, which must always imply reducing costs.

The task is to examine and measure the resources expended, isolating the factors or functions where efficiency affects the final result, and relate these to a measure of the product. This examination must be carried out in retrospect to enable plans to be formulated for further and continual improvement. The task must be approached in the frame of mind which does not accept that anything which is being done at present is performed in the best way. It is, in principle, as simple as the analogy of a racing motorist, who must carefully time his test runs to know the effect of each change in the factors or circumstances which affect his performance. It is in application, complicated by the great number of factors and varying circumstances in our modern industrial structure.

Circumstances

Varying circumstances have to be contended with according to the nature of production and type of product. The following classification serves to illustrate the variety, while at the same time it establishes concise terms which can subsequently be used without repeated qualification.

In attempting this classification it is appreciated that all productions and products will not necessarily fall precisely within one or other of the headings and, indeed, there may be some industries to which the terms do not apply at all.

The nature of production can be referred to under five main headings:—

- (a) Continuous Processes, exemplified in paper making, steel production, chemical manufacture, electricity generation, etc., and where the process is continuous, complex and involving the use of expensive plant.
- (b) Mass Production, exemplified in the manufacture of cigarettes, electric lamps, bricks, etc., where the quantity is high, complication and variety comparatively low, and where mechanisation should be highly developed.
- (c) Line Production, exemplified in the production of motor vehicles, wireless sets, etc., where quantity is high and the comparatively complicated products progress through a series of processes which, while consistent in nature over fairly long periods, must be adaptable to changes or modifications.
- (d) Batch Production, exemplified in the production of the bulk of domestic and office appliances, clothes, furniture, machine tools, etc., where specific quantities of component parts and assemblies are progressed to a completion or final assembly stage.
- (e) Jobbing, exemplified in engineering development work and small quantity manufacture of specification products where the product is subject to infinite variety, but the manufacture may be grouped by such qualifications as trade or degree of precision.

In making reference to the above main headings of nature of production some further qualifications will be necessary, and in general can be covered by the following sub-headings:—

- (i) Self-contained production, where all the processes are carried out from raw material to finished product, with the exception of relatively few bought-out, part finished, or finished items.
- (ii) Aided production, where, contrary to the above, a great many items are bought-out.
- (iii) Short-cycle production, where the process time from material to finished product is comparatively short.
- (iv) Long-cycle production, where the process time from material to finished product is comparatively long.

Type of Product.

Other than in giving specific example, reference

to product can be made in the following broad terms:—

- (a) Stable Products, where the product is firmly established with a minimum of variety and is slow in development.
- (b) Progressive Products, where the product is fairly new, subject to rapid development and with considerable variety.
- (c) Specification Products, where the product is made to measure and subject to more than considerable variety.

Without proceeding to a more detailed consideration of these greatly varying circumstances it is not difficult to appreciate the comparative simplicity with which a measure of resources expended can be related to the mass production of a stable product like, for instance, cigarettes, and on the other hand to realise the complications attending the relating of resources expended in jobbing manufacture to a measure of progressive specification products. In the latter instance, both the resources and the products are subject to continual change and wide variety.

Factors

Before considering ways and means of relating a measure of resources expended to a measure of product, it is desirable to list and examine the principal factors which contribute to this broader conception of productivity.

- (a) *Design.* Under this heading is included everything which contributes to the establishment of the specification of the product. Designers and draughtsmen in the research, development and production phases of a product must have as much regard for economy in the expenditure of resources needed for its manufacture as for efficacy of the product. At the same time there is need for speeding up the introduction of new products. In the engineering industry in particular, greater regard in the research stage for economy in the expenditure of production resources would save time and money in the subsequent development and production stages. Designers should never be reconciled to a short batch outlook. Appoint a standardisation officer but do not lean on him—help him. Many differing components could be designed so that the raw material and several initial operations are common, thus making possible larger batch production of stock components with considerable saving in cost.
- (b) *Method.* This factor includes all the functions which usually fall under the heading of Production Engineering. In the engineering industry this would include planning, rating, time study, tool making, small tool utilisation, methods research, plant design, works layout, etc. Improvement of method probably holds out the greatest hope for the future providing we are enabled to embark upon adequate

policies of capital investment. Introduction of new methods and plant must be proceeding all the time, but must not detract from obtaining the best utilisation of the existing plant. Sometimes a simple change in procedure renders existing plant as effective as a new alternative and saves in capital investment. However, the injection of new methods and plant and the use of greater mechanisation must not be delayed so that it is virtually a blood transfusion in order to keep the patient alive. Employ a Plant and Methods Engineer with a roving commission, but ensure that he is accepted by, and in constant consultation with, shop floor supervision, and is prepared to arrange things so that the foremen are left with the feeling that they have had a considerable say in the choice of plant and thereby have a stake in its ultimate success.

- (c) *Facilities.* This heading, like design and method, is a constructive factor and embraces all remaining functions which are constructive in their relation to either plant or operator process. Facilities include the provision of suitable and adequate buildings, services, transport, progress, training, welfare and cleaning, etc. These facilities contribute to the skill, activity and application of operators, and the effective utilisation of process plant. In all constructive factors it is possible to indulge in false economy and it is therefore important to attempt a comparison between the additional expense of improvements and the resultant saving in product cost.
- (d) *Activity.* Activity embraces all process time and resources effectively spent by process operators or spent in the effective utilisation of process plant, or, of course, a combination of both. This is another way of expressing what is more loosely referred to as direct labour and expense. It will be shown later that the time element of this factor is so fundamental that it can be used as a measure of product and the basis for an expression of year by year improvement due to method change.
- (e) *Application.* This is a negative expression to account for process-losses in terms of time and expense *not* effectively spent by operators or in the utilisation of plant. In other words, the time and money spent due to *lack* of application and which, under ideal circumstances, would come under the previous heading of activity. This factor can, in practice, be greatly influenced by the factor referred to as "Facilities."
- (f) *Quality.* This embraces all forms of inspection and test functions which should really be regarded in the light of an insurance policy. When all is said and done plant is procured and operators employed to do the job properly. The amount of insurance premium to ensure quality depends on the risks taken which in

turn, depend to a great extent on the previous five productivity factors. Thoughtful design, good methods, helpful facilities, effective process plant and skilful, conscientious operators can greatly reduce the risk of poor quality and production losses due to scrap.

- (g) *Supervision.* This embraces all shop floor supervision. In the engineering industry this would embrace setters, chargehands, foremen and shop managers. To a great extent the same can be said for supervision as for inspection, as much can be done in design, method and facility to reduce the need for supervision.
- (h) *Administration.* This factor includes top management and all commercial activities such as buying, general offices, wages, cost office, accounts, stores, etc. There can be no doubt that much remains to be done toward improving the efficiency of administration in its relation to production. Commercial managers, chief accountants, cost accountants and stores managers must have full regard for the direct and indirect economies which can be effected by modern systems and mechanisation in offices and stores. On the other hand design and method must have full regard to the cost of administration, bearing in mind that in most works' accounting systems, the accounts are built up from elements of process time and cost. All too frequently, time and money is spent in calculating to unnecessary degrees of accuracy and this practice is all too often extended by the introduction of calculating machines and the pernicious decimal system. To put this contention to the test, consider the frequency with which time allowed is calculated to decimals of a minute, while the time taken is recorded to the nearest tenth of an hour. Even a little investigation in this direction may lead to saving in office time and expense. Similarly, administration time and effort will be reduced by rationalisation of product and process and simplification of procedure. Administration must be relieved of any unnecessary work in order to devote full attention to the important task of accounting for management control, and thus make its full contribution to improve productivity.
- (i) *Maintenance.* This factor covers all forms of maintenance of buildings, plant and services. Its contribution toward the reduction of process losses by the maintenance of good facilities is obvious. Records resulting from an effective maintenance control can contribute greatly in the choice of new, and the improvement of existing plant and methods. The greatest contribution to improved productivity and economy in maintenance expense probably results from properly organised preventative maintenance as opposed to a breakdown service. There is a great deal to be said for the old proverb about a stitch in time.

- (j) *Material.* Choice of material has, of course, a considerable bearing on productivity. It is introduced as a separate factor, because it is usually treated as a separate item of cost and indeed, properly so. Choice and control of material and other bought-out items fall under the previous headings of Design, Method and Inspection.

The principal factors contributing to productivity are then :— Design, Method, Facilities, Activity, Application, Quality, Supervision, Administration, Maintenance and Material. The extent to which each contributes depends on the nature of production and type of product. In the highly mechanised continuous processes and mass producing units, plant design, method and maintenance play a greater part than does the skill and application of the production operative. It is nevertheless, important to be able, in some measure, to relate changes in productivity and cost to changes under headings approximating to these factors, so that we can see the effect of variations in the manner we are expending our resources. It is comparatively easy to do this if we are engaged in the mass production of one single stable product by one comparatively simple short cycle method of production. The aim, however, is to stimulate thought in the minds of those responsible for the expenditure of resources in the manufacture of far more complicated products by complex and long cycle methods of production.

Resources

There are two fundamental units of measure—time and money. These are related in the old method of costing still quite widely used—labour plus overheads. Americanised, this is expressed as labour plus burden. It would be paradoxical to continue to regard as burdens such productivity factors as design, method and administration to mention but a few. No, the answer is that much more must be learned about the expenses that for so long have been wrapped up in that all embracing term “overheads”. These must be examined as critically as have been examined the direct labour or process time elements. To be able to examine it is first necessary to dissect, isolate and then classify the headings under which resources are being spent. It is possible that too much is being spent under some headings while under others there is a penny wise and pound foolish policy. It might be opportune again to consider the racing motorist. It is first essential to get to know the machine. It is then necessary in making adjustments to be able to measure the effect of each on the speed of the machine. It may be clearer now if this analogy is expressed in industrial terms. Let it be assumed that one industrial process previously performed by hand methods is now mechanised. A few of the operators are trained to operate the new plant, while the majority are trained to fulfil other functions regarded

as indirect, such as maintenance engineers to maintain the new plant, planning engineers to plan the work; we might even stretch the imagination far enough to suggest that the remainder become salesmen to sell the greater output mechanisation has made possible. What has been achieved? Direct labour has been considerably reduced while there is a considerable increase in indirect expenses such as plant depreciation, running costs, method planning, administration and possibly increased floor space which is more expensive in rent, rates, heating, etc. Productivity has been increased, or has it? More is being produced but is it with less expenditure of resources or more? This puts the problem in a nutshell. If the unit of measure of resources is money, what is the unit of measure of product needed to enable this important question to be answered?

Process

As mentioned previously, the unit of measure of a simple stable product can be the quantity produced as, for instance, the number of cigarettes produced can be related to the measure of resources expended, thus revealing the change in productivity resulting from change in circumstances. But what if the product is complex and ever varying? It is necessary to look for something which, in spite of these variations, is reasonably constant or stable. Product is usually some form of raw material which is changed in form or character to make it into a saleable product of enhanced value. To do this we have to possess “know-how” or skill which has value measured in terms of wages or salaries. The physical or chemical changes applied to the material can generally be described as a series of processes with reasonably clear lines of demarcation between each. When product is sold it is really the selling of raw material plus process. If it is possible to catalogue these processes so that irrespective of variation in the size, make-up or function of the final product it can be accounted for in varying proportions of process, then process can be the stable cost basis we are looking for. If, also, it is possible to establish the cost of applying each process in terms of money per unit of time, then there is the basis for integrating the costing system with the financial accounts and into the bargain, we get a sound basis for operational control or accounting for management control.

Control

Until comparatively recently, costing could be described as historical costing in so far as costs were based on past performance and whereby variations from either previous costs or estimates were only revealed after the completion of the product, possibly after it was sold and frequently, so long after that investigation into the causes of variation proved a lengthy, costly and frequently abortive procedure. The subject, Standard Costing and Budgetary Control, frequently engenders in the minds of the uninitiated a fear of the unknown, possibly due, without any disrespect for the accounting profession, to the accounting jargon necessary to describe the

considerable amount of detail work involved in applying such systems to the complicated structure of modern industry. If, however, an industrial unit is considered as being, irrespective of size, a collection of separate processes only interdependent when related to the final product, it is easier to understand this modern approach to costing and management control. Let each process be considered as a separate business, in which case no objection would be raised to costing the product in terms of time by process. If then, each expenditure of resources attributable to a process is budgeted we can arrive at a budgeted cost of the process at a given level of production. The next step is to account for the actual expenditure of resources period by period, relate these to the amount of process achieved and compare with the budget. This is done irrespective of the amount and nature of the final product. The differences between actual and budgeted cost of the process serve as a measure for control in the expenditure of resources, as differences can readily be traced to any particular resource where expenditure has not reached or exceeded the budget. Such systems have many advantages in the establishment of prices, control of costs and perhaps, most important, the control of the production activities.

This Paper is particularly concerned with the ability, under such systems, to break down costs under headings of expenditure of resources accurately related to a measure of process or product.

Time

Time is the most common unit used as a measure of process but it must be quite clear what sort of time. Piecework and incentive bonus schemes have introduced into industrial terminology several sorts of time. Base time, time allowed, time taken, standard hours, clock hours, etc. Time allowed is frequently referred to in terms of standard hours or standard minutes, and there could not be a more misleading title. Far from being standard, it is the one sort of time which varies considerably in different industries and different parts of the country, according to the amount of bonus it is desired that the operator should be capable of earning, and as such is useless for the evaluation of process and thereby, product. Time taken is equally unsuitable, for it reflects the speed of working of operator or machine. If base time is understood to be the time it is considered the job should be performed in, by that mythical person, the operator of average ability, or by a normally efficient machine, or a combination of both, then base time is the proper measure of process. Vigorous steps are now being taken to improve the standard of work evaluation by time study and other methods, and the subject will soon take its proper place in our educational curricula.

While the use of base time as a constant measure of process eliminates the variation in speed of working, it does not, however, eliminate variations due to the introduction of new methods.

Method

Improvement of method, both by better utilisation of existing plant and by the introduction of new

plant, is the principal means whereby productivity will be improved. It is important that any measure of process should reveal method improvement which can have the effect of increasing capacity and reducing costs. Again, the less stable the product and the more complicated the production, the more difficult it is to establish this constant measure of product, even although it has been broken down into a series of processes. However, one system can be described and this system is proving practical in the case of batch production of a progressive and somewhat complicated long cycle specification engineering product. A series of typical component parts and assemblies were carefully selected as representative of the sort of production that would obtain for some years and involving all the existing processes. The purpose is to establish a constant measure of product over a reasonable term of years starting from a base year and in this instance 1950 was chosen. Base times by process were established for the selected parts and assemblies, using methods in vogue in 1950. This was repeated each succeeding year using current methods, and by the reduction in the base time a factor for each year by each process reveals the improvement in method. In expressing this, 1950 is represented as unity or one basic hour and the reducing figure for succeeding years is referred to as the method index. These method index figures enable both product and capacity to be measured in terms of 1950 base time, always referred to as basic hours. When a new final product is introduced and planned it is evaluated by process in terms of current base hours. The current base hours are then uplifted to 1950 basic hours by applying the method index, and thus the new product is evaluated in terms comparable to all other products. So far this reveals the improvement in method in terms of time that should be taken by the average operator or normally efficient machine. A reducing method index figure indicates that productivity has been improved—or again, does it?

There are other variables to be taken into account. For instance, some of the resources expended are fixed or in other words they do not rise and fall with variations in output. If the extra capacity made available by improved methods is not filled up, then there is a waste of some of these resources which are of the fixed nature. To improve methods there is probably an expenditure of financial resources in capital investment with a resultant increase in depreciation. With greater mechanisation there is a need to increase production engineering staffs, maintenance staffs and power consumption in proportion to the direct process.

Having satisfactorily proved that less time is taken to produce a constant measure of product the probable increase in the expenditure of indirect resources must not be overlooked.

Progress

How is it possible to be sure that reduced base time for a constant measure of product represents improved productivity?

STATEMENT A

| | 1950 | | | 1951 | | | 1952 | | | 1953 | | |
|--|---------------------|----------------------|----------------------|---------------------|----------------------|----------------------|---------------------|----------------------|----------------------|---------------------|----------------------|----------------------|
| METHOD INDEX (One 1950 Base Hour equals One Basic Hour) | 1.0 | | | .9 | | | .8 | | | .7 | | |
| ELEMENTS OF COST | Per Base Hour | Per Basic Hour | At 1950 Levels | Per Base Hour | Per Basic Hour | At 1950 Levels | Per Base Hour | Per Basic Hour | At 1950 Levels | Per Base Hour | Per Basic Hour | At 1950 Levels |
| | £Dec | £Dec | £Dec | £Dec | £Dec | £Dec | £Dec | £Dec | £Dec | £Dec | £Dec | £Dec |
| DIRECT EXPENSE | .20 | .20 | .20 | .24 | .216 | .18 | .24 | .192 | .16 | .28 | .196 | .14 |
| INDIRECT VARIABLE EXPENSE | .20 | .20 | .20 | .28 | .252 | .21 | .36 | .288 | .24 | .42 | .294 | .21 |
| INDIRECT FIXED EXPENSE | .10 | .10 | .10 | .12 | .108 | .09 | .15 | .120 | .10 | .14 | .098 | .07 |
| TOTAL PER BASE HOUR | .50 | | | .64 | | | .75 | | | .84 | | |
| TOTAL PER BASIC HOUR | | .50 | | | .576 | | | .60 | | | .588 | |
| TOTAL PER BASIC HOUR AT 1950 LEVELS | | | .50 | | | .48 | | | .50 | | | .42 |

The first and rather obvious answer is to examine the cost of this constant measure of product year by year. Providing a costing system is employed which reveals the all-in cost per process base hour, it is a simple matter to adjust this to cost per basic hour by multiplying by the method index figure. However, over recent years, the cost effect of any improvement in method has been off-set by increasing rates of pay. To adjust accurately, and in detail, for this increasing cost of the resources expended would prove a formidable task. There is, though, a comparatively simple short cut which can prove extremely helpful if the process costing rate is built up of elements of cost of functions which are controllable by management.

In Statement A, fictitious figures are used in an over-simplified illustration of this short cut. This, and the succeeding statements cover past, present and future, as indeed should all such statements and could represent total cost per process or total cost of all processes. In Statement A the method index indicates that processes which required one base hour in 1950 only required .9 hours in 1951 and .8 hours in 1952. For 1953 the method index is budgeted

as .7 hours. The process costing rate is simply divided between direct expense, indirect variable expense and indirect fixed expense. Three figures are given for each element of cost for each year. Firstly, the current cost per base hour. Secondly, the cost per basic hour in the next column, which is arrived at by multiplying the cost per base hour by the method index figure. This second column is therefore a true reflection of product cost, excluding raw material cost. In the third column the cost is reduced to 1950 levels. To do this the direct element of cost is first arrived at by multiplying 1950 direct cost by the current method index figure, thus arriving at the cost, assuming there had been no increase in wage rates.

The indirect elements of cost are then reduced in proportion to the current cost per base hour. All three figures are, of course, the same for 1950 which is the datum year. The first line of totals show the year by year increase in process cost per base hour which reflects the increase in wage rates. The second line of totals are cost per basic hour, and show the extent to which the increase in wage rates has been off-set by improved method and whereby the year by year increase is less. The third line of totals indicates

the cost per basic hour of process at 1950 levels, assuming that the increases in indirect expenses have followed the same pattern as for the direct expense. The figures for 1952 have been arranged to show the effect on process cost of failure to achieve a method improvement proportionate to the increase in the indirect expenses, and also the effect of failure to fill up the extra capacity made available by the method improvement.

Looking at the 1952 figures adjusted to 1950 levels, it will be seen that while the direct cost has been reduced to £.16 the indirect variable has increased to £.24, thus fully offsetting the direct cost saving due to method improvement. Also, while capacity has been theoretically increased by 20% the indirect fixed element of cost remains at £.10 per basic hour, indicating that the extra capacity has not been filled, otherwise the fixed elements of cost could have been spread over the greater production of basic hours of process. As a result the adjusted total cost at £.5 shows no improvement over the 1950 figures. The budget for 1953 shows how it is planned to put this matter right. It is planned to obtain further method improvement without increasing the proportion of

indirect variable expense to direct expense. It is also planned to fill the extra capacity made available by improved method and thus reduce the proportion of the indirect fixed expense. The result is, that in spite of a further increase in wages rates the product cost is reduced in terms of process to £.584 per basic hour, and the cost adjusted to 1950 levels show at £.42, a 16% reduction on 1950.

All this cannot, of course, be achieved by merely examining such simple elements of cost. It is necessary to break down the elements of cost under such account headings as, according to the nature of production and type of product, will enable management to shape the future. Also, of course, the figures will not prove in practice to be as simple or as spectacular as those in statement 'A'. The figures in statement 'B', while also fictitious, do present a more realistic pattern and illustrate trends that might be found in practice. Although not so spectacular, figures for 1952 again reveal that method improvement has somewhat lagged behind the increase in indirect expenses. Also, the adjusted indirect fixed expense indicates that either there is an increase in this nature of expense or a lack of

STATEMENT B

| | 1950 | | | 1951 | | | 1952 | | | 1953 | | |
|--|---------------------|----------------------|----------------------|---------------------|----------------------|----------------------|---------------------|----------------------|----------------------|---------------------|----------------------|----------------------|
| METHOD INDEX (One 1950 Base Hour equals One Basic Hour) | .10 | | | .971 | | | .938 | | | .916 | | |
| ELEMENTS OF COST | Per Base Hour | Per Basic Hour | At 1950 Levels | Per Base Hour | Per Basic Hour | At 1950 Levels | Per Base Hour | Per Basic Hour | At 1950 Levels | Per Base Hour | Per Basic Hour | At 1950 Levels |
| | £Dec | £Dec | £Dec | £Dec | £Dec | £Dec | £Dec | £Dec | £Dec | £Dec | £Dec | £Dec |
| DIRECT EXPENSE | .219 | .219 | .219 | .231 | .223 | .213 | .246 | .231 | .201 | .262 | .240 | .194 |
| INDIRECT VARIABLE EXPENSE | .120 | .120 | .120 | .124 | .121 | .114 | .127 | .119 | .104 | .132 | .121 | .098 |
| INDIRECT FIXED EXPENSE | .163 | .163 | .163 | .177 | .172 | .162 | .200 | .187 | .163 | .203 | .186 | .151 |
| TOTAL PER BASE HOUR | .502 | | | .532 | | | .573 | | | .597 | | |
| TOTAL PER BASIC HOUR | | .502 | | | .516 | | | .537 | | | .547 | |
| TOTAL PER BASIC HOUR AT 1950 LEVELS | | | .502 | | | .489 | | | .468 | | | .443 |

STATEMENT C

| | | | 1950 | | | 1951 | | | 1952 | | | 1953 | | |
|--|---|--|---------------------|----------------------|----------------------|---------------------|----------------------|----------------------|---------------------|----------------------|----------------------|---------------------|----------------------|----------------------|
| METHOD INDEX (One 1950 Base Hour equals One Basic Hour) | | | 1.0 | | | .971 | | | .938 | | | .916 | | |
| ELEMENTS OF COST | | | Per Base Hour | Per Basic Hour | At 1950 Levels | Per Base Hour | Per Basic Hour | At 1950 Levels | Per Base Hour | Per Basic Hour | At 1950 Levels | Per Base Hour | Per Basic Hour | At 1950 Levels |
| | | | £Dec | £Dec | £Dec | £Dec | £Dec | £Dec | £Dec | £Dec | £Dec | £Dec | £Dec | £Dec |
| DIRECT LABOUR | V | | .151 | | | .160 | | .147 | .174 | | .142 | .186 | | .138 |
| DIRECT EXPENSE | V | | .052 | | | .054 | | .050 | .055 | | .045 | .058 | | .043 |
| DIRECT EXPENSE | F | | .016 | | | .017 | | .016 | .017 | | .014 | .018 | | .013 |
| GENERAL WORKS | V | | .110 | | | .113 | | .104 | .115 | | .094 | .119 | | .088 |
| GENERAL WORKS | F | | .064 | | | .069 | | .063 | .089 | | .073 | .090 | | .067 |
| ADMINISTRATION | F | | .094 | | | .103 | | .095 | .105 | | .085 | .106 | | .079 |
| SUNDRY CHARGES | V | | .010 | | | .011 | | .010 | .012 | | .010 | .013 | | .010 |
| SUNDRY CHARGES | F | | .005 | | | .005 | | .004 | .006 | | .005 | .007 | | .005 |
| TOTAL PER BASE HOUR | | | .502 | | | .532 | | | .573 | | | .597 | | |
| TOTAL PER BASIC HOUR | | | | .502 | | | .516 | | | .537 | | | .547 | |
| TOTAL PER BASIC HOUR AT 1950 LEVELS | | | | | .502 | | | .489 | | | .468 | | | .443 |

utilisation of the increase in capacity resulting from improved methods.

In the over simplified illustration in statement 'A' the whole of the direct expense was adjusted by multiplying the 1950 figure by the method index. In practice this adjustment should only be applied to the direct labour element of direct expense. This part of the adjustment will be seen in statement 'C' where the process cost is broken down into further elements. In this statement, the detail costs per basic hour have been omitted to remove some of the apparent complexity of a lot of figures.

While it may be considered that the detail of these statements is deserving of some quiet contemplation, the significance of the total costs per basic hour are obvious. Providing it can be accepted that elements of process cost move with wage levels, then this short

cut provides a means for determining if productivity has been improved or not. What is more to the point is that such statements can be tools for management in establishing a measure of progress as a guide in framing the future.

RESEARCH PUBLICATIONS

A number of copies of the following Research publications are still available to members, at the prices stated:

Report on Surface Finish, by Dr. G. Schlesinger 15/6
Machine Tool Research and Development 10/6
Practical Drilling Tests 21/-

These publications may be obtained from the Production Engineering Research Association, "Staveley Lodge", Melton Mowbray, Leics.

INDUSTRIAL DEVELOPMENT OF POROUS CERAMICS

by J. E. POULTER, Grad.I.Prod.E.

Presented to the London Graduate Section of the Institution, 27th May, 1952.

For the past three and a half years Mr. Poulter has been a ceramic development engineer with the Royal Doulton Potteries, London, concerned mainly with the production of porous ceramics.

He was apprenticed as a toolmaker with Vickers-Armstrongs Limited of Weybridge, Surrey. After further experience in several departments he was for three years a Jig and Tool Draughtsman with Foster Transformers and Switchgears. Subsequently he worked with a furniture manufacturing company, and also as a Production Engineer with a company manufacturing ceramic insulators.

This Paper by Mr. Poulter, who is a Past Chairman of the London Graduate Section, gained the Institution's Hutchinson Memorial Award, 1952.



Mr. J. E. Poulter

THE term "ceramic" is usually used to define those materials made from clays, and other earthy materials and metal oxides. For example, china, earthenware, electrical porcelain, refractories and even glass and vitreous enamel can be said to be ceramic material.

These materials, apart from being made from materials having similar origins, are produced by a generally similar process, namely mixing and preparation of the raw materials, shaping to the required form, and then firing in a kiln. The exceptions to this procedure are glass and vitreous enamel, which are made by mixing and then firing the mixture until it melts and forms a viscous fluid.

The basic raw materials, that is clays, silica and other metal oxides are, before firing, all fine powders or materials having a highly porous nature. The clays are themselves made up of very fine particles of material which have a 'platy' or lamellar form, the china clays being comparatively coarse, the Devon ball clays finer, and the Dorset ball clays finer still. The metal oxides and quartz are usually very finely ground powder. In the preparation of a 'body' the ingredients are mixed together and brought, by various processes, into a 'clay' condition. In this condition the mixture is very porous and will absorb a lot of water due to the fine pores throughout its mass. In the clay condition the piece can be shaped ready for firing.

In the case of firing a clay 'body' (it may be a cup, an insulator, or even a large piece of chemical plant) the firing process usually brings about a change

in the general structure or condition of the clay body known as vitrification or part vitrification. When a body is said to be 'vitrified', it is usually assumed to have no porosity. In the change from the clay body to the vitrified body we have changed from a very porous structure to a structure having no porosity. The changes brought about can be better understood if we consider the phases a piece of bone-dry clay passes through when in the kiln.

At the time of entry into the kiln it should be thoroughly dry and contain no more than 2.3% of free water. The first effect of the heat is to evaporate this water. During the next stage of heating, roughly between 250°C. and 550°C., the combined water from the clays is driven off. If any organic matter is present, it is usually burnt off at this stage or just later. At approximately 1050°C. or a little higher, dependent on the nature of the alkalis in a normal body, the feldspar begins to melt. As the temperature is increased, more of the feldspathic material becomes fluid and tends to combine with the silica and alumina constituents to form mullite, and a form of silica known as tridymite. Thus, the firing process is one of partial fusion; the molten feldspar, being a viscous liquid, fills the pores by capillary action until the porosity is nil. When the ware has reached its point of minimum porosity, or its desired porosity, the firing process is said to be complete. After cooling the ware is said to be 'vitrified', and it is usually characterised by a conchoidal fracture.

If the temperature is increased above the vitrification temperature the ware 'bloats', that is, blisters



Some of the various types of low-resistance porous ceramic diaphragms used in electrolytic processes.

and distorts, due to the generation of gas inside the body.

Thus a normal clay body will, on firing to a vitrification temperature, change from a highly porous clay material to a dense non-porous material. If the firing operation be stopped before the vitrification temperature is reached, then a material will be obtained having a porous structure. This is usually the method used for obtaining cheap porous products, or those in which controlled porosity is not required. Most ceramic materials are strongly resistant to all acids, with the exception of hydrofluoric and hot concentrated phosphoric acids. They are also resistant to high temperatures, but not to thermal shock. The mechanical strength depends on the nature of the raw materials, but it is always assumed that ceramic materials are weak in tension and strong in compression.

In this brief survey of the processes used in ceramic manufacture and the characteristics of the resultant product, the writer has attempted to show the basic problems that underlie all ceramic materials, and in particular how those problems can limit certain developments mentioned later.

The structure of the material before it reaches vitrification consists of a large number of small particles becoming partially sintered together. The particles consist of the plate-like particles of the clays and the larger particles of crushed siliceous materials

and feldspars. The degree of porosity varies according to the degree of vitrification.

In the case of industrial porous ceramics, the particles which make up the whole are chosen for the properties which they confer on the finished material. The size of particles compared with clays can be very large, but they are chosen for their influence on the properties of the porous products. These large particles are vitrified, and have the same properties as normal ceramic materials, namely, high resistance to acids, and comparative by good resistance to high temperatures.

The structure of a coarse grade porous ceramic material can be compared with a box of tennis balls, which are glued together at the points of contact. In a porous ceramic the particles are graded to similar sizes and sintered together with a thin glaze film at the points of contact. For practical purposes the particles can be compared to spheres. The voids between the spheres are the pores and it is the pores which control the properties.

It must not be thought that all porous materials are constructed in the same way. Some of the raw materials which are used, such as Kiesulguhr, have a very open structure and confer high permeability but low mechanical strength on the finished product.

Tests

By careful control of the raw materials used and the manufacturing processes, the properties of porous ceramics can be carefully maintained and forecast, but it is essential to have tests to ascertain certain properties when specified or sold to specification.

The usual tests by which porous ceramics are controlled are maximum pore size, permeability or absolute permeability, and apparent porosity. All these properties require special tests, but before outlining the method of test the terms should be defined.

The term 'maximum pore size' is self-explanatory, as it is the diameter of the largest pore in the piece under consideration. On the Continent some makers use the term 'pore radius' when referring to pore size.

The pores, though they are interconnected, are considered, for the purposes of tests, as a straight capillary tube. In practice the pores are not straight capillaries, but very irregular in shape and of varying diameter. As the test only measures the smallest diameter of the largest pore, it is an extremely effective method of measurement.

The test is usually carried out by soaking the piece of porous ceramic in water for at least two hours, or alternatively it can be soaked under vacuum. When the last piece is thoroughly soaked air is pumped into it gradually, and when the first bubbles arise through the liquid the pressure is noted. From this pressure the maximum pore size can be calculated. The calculations are straightforward and depend on natural laws of capillarity.

The pore size test is usually used for control purposes on fine grade materials where accurate

measurement of pore size is essential. The coarse grade materials are not usually compared by pore size tests but by permeability.

Apparent Porosity

The ability of porous ceramics to absorb liquids is in some cases a most important property and one which is partly controlled by the pore volume of the material.

The pore volume of the material can be readily calculated when its apparent porosity is known, as it is expressed in terms of a percentage of the total volume.

The test to determine apparent porosity is simple. The piece to be tested is dried, carefully weighed and then immersed in water for a reasonable time until thoroughly soaked. The piece is then removed from the water, the excess being wiped off, and reweighed. The piece is then weighed again, whilst it is suspended in water.

Let W_1 = Dry weight of the sample

W_2 = Wet weight of the sample

W_3 = Weight of the sample when suspended

Then % apparent porosity = $\frac{W_2 - W_1}{W_2 - W_3} \times 100$

If the pieces are soaked in a vacuum chamber, values 1% or 2% higher can be obtained as the pores are more effectively filled.

Permeability

The permeability of the ceramic is a most important function of a porous ceramic, and in the case of a material for filtration purposes is one which must be considered accurate. For practical purposes the permeability is measured in rate of flow per unit thickness, per unit area x length of time. The measurement is usually expressed in terms of galls./sq. ft./hr./1" of thickness or in cubic feet/sq. ft./min. for a known pressure drop. Most measurements for industrial grades are given for a 1" pressure drop.

The usual method of test is to use a candle or disc, supply liquor to it under a certain head of water and measure the rate of flow through the piece being tested. This test is straightforward, and for check purposes is reasonably accurate. This type of test is most useful when a new plant is being considered.

From the structure of the porous ceramic material, and consideration of its general properties, namely the ability to pass gas and liquid, one can readily realise what great applications it has as an engineering material.

So far the greatest field of application has been in the chemical industry, where the acid resisting properties of the material have been fully exploited.

The ability of a piece to pass liquid or gas has led naturally to its use as a filter material. As the finer grades of material only allow small amounts of liquor to pass, they have found use in electrolytic processes.

Porous Ceramics in Filtration

Filtration has become one of the most widely used processes in modern industry. Almost every product relies to some extent on the use of filters to improve quality or characteristics, it may be for the cleaning of gas or liquids.

Gas Filtration: In the filtration of gases there are three broad methods in present use:— (1) The use of a wet filter which effectively scrubs the gases; (2) Electro static precipitation which removes particles; (3) The multiple path filter, such as a textile or hair filter, sintered metals, porous ceramic and the edge type filters.

In this Paper consideration will only be given to porous ceramic filters. Earlier it was mentioned that the greatest field of application has been in the chemical industry, where the resistance of the material to corrosive conditions was of prime importance. Porous ceramics resist all acid gases with the exception of hydrofluoric. Recently the engineering industries generally have shown considerable interest in this material as a filtration medium due to its exceptional properties, as mentioned previously.

The wide range of pore sizes in which the material is available has enabled the filtration of gases to be carried out with a very fine degree of discrimination.

Modern methods of production have enabled single filter elements up to 4' 6" long to be produced, thus enabling filter units capable of handling large amounts of gas to be constructed, with a comparatively small number of tubes. In some cases the filters can be operated with pressure drops as high as 12 - 15 lbs./sq. in. This high pressure drop is not



Group of porous ceramic filtering materials.

necessarily due to the resistance of the filter, but to the burden of dust that is deposited on the wall of the filter.

The introduction of the fluid formed catalyst bed as part of the processing of hydro-carbon chemical products has led to the use of filters for the collection of the catalyst dusts, as they pass out of the catalyst cracker with the cracked vapours. This is an example where the dust is collected to achieve two objects:— (1) To maintain quality of the product; (2) To recover catalyst. Further uses for installations using porous ceramic filters are in the collection of valuable dusts from fine grinding operations. It has been common practice for many years to recover the dusts by means of a cyclone or separators working on a cyclonic principle. The cyclones do not usually collect the fine particles below 20μ and the fine dusts carry over through the cyclone exit. Usually cloth bag filters have been installed as an extra aid to prevent the dusts reaching the atmosphere.

Cloth filters, when compared with porous ceramic filters, suffer from the following faults:—

1. Only low pressure drops of the order of a few inches of water pressure can be tolerated with consequent low flow rates.
2. The filter cloths have a comparatively short life.
3. They are not completely inert.
4. As they are made from organic materials they will not operate at elevated temperatures.
5. Rapping gear is required to dislodge the dust particles and maintain a good clean filter.

The usual method of cleansing porous ceramic filter elements is by back flushing, or blowing back with filtered gas or air after a pre-determined time. On most plants, the filters are usually assembled in one or more units, in order that each unit can be isolated for cleansing whilst the remaining unit or units will continue with filtration. Thus a continuous cycle is possible. With this type of installation the only moving part required is the valve gear for gas reversal.

For most cases of large scale industrial gas filtration comparatively coarse grades of ceramic, having pores between 75μ and 125μ have been used. It should not be thought, however, that these materials have only been used on large installations where dust recovery or control is a considerable problem. Some modern machine tools are being fitted with porous ceramic air filters on the pneumatic control lines. This is a conventional application where the solids are retained in a sump to be removed with cleaning water droplets. This type of filter is also being used to an increasing extent as an air filter fitted to instrumentation and control lines in modern remote controlled chemical plant.

It is extremely rare to find the very fine grades of porous ceramic being used as an air filter, since the pores, being small, give a very low permeability with consequent low gas yields. They do, however, find an application in laboratory work where clean air is essential.

Liquid Filtration: It is in the field of liquid filtration that porous ceramics have been most widely known. Most of us are familiar with the water filters which are made by many companies throughout the world. Developments from these beginnings have led to the modern industrial applications. The chemical industry, looking for a material which would withstand the chemicals and acids in general production, quickly realised that porous ceramic was an ideal material for their application since it was resistant to most acids, would withstand comparatively high temperatures and also had a fairly high mechanical strength.

In the chemical industry the widest application has been the clarifying of liquors and removing particles of foreign or deleterious matter.

Again, in this application the effective range of grades for possible use is so much wider than for gas filtration. The ultimate choice of pore size for a certain task is dependent on the type of liquid being filtered and the nature of the suspension in the liquid. It is commonly thought that the increased resistance of a porous ceramic element when compared with other types of filter element gives lower rates of filtration. In actual practice, the rate of filtration depends more on the permeability of the filter cake than on the resistance of the filter media.

At present, continuous filters using porous ceramic elements have not been fully successful, but certain investigations are being made into the problems set by such plant.

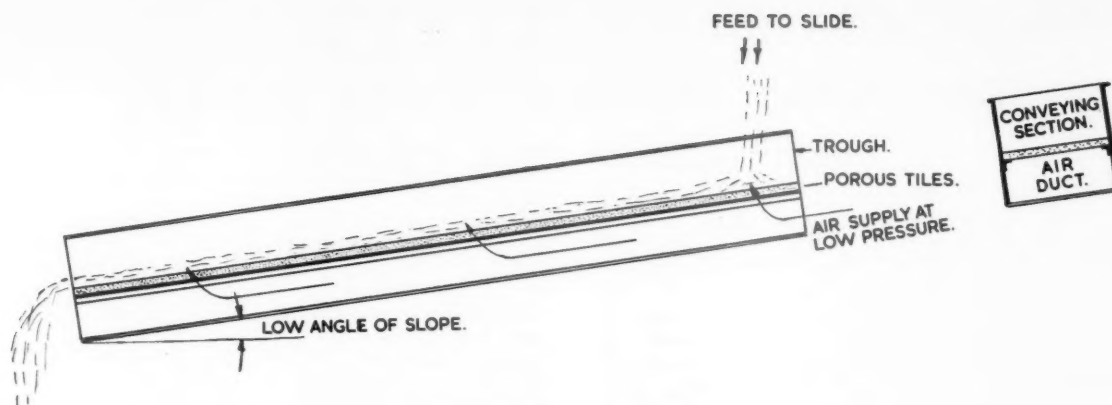
The most interesting developments in industrial filtration have probably taken place in the pharmaceutical and allied industries, where fine grade porcelain filters are becoming increasingly widely used.

In the late 19th century, Professor Louis Pasteur developed a fine grade porcelain filter with which he found he could prevent the passage of bacteria. He thus produced a filter with which he could prepare sterile solutions, as bacteria would not pass through the filter. Since this discovery, many workers have studied the use of these filters, as a production process, but until recently little reliability could be placed on their use. More effective methods of control by the filter manufacturer, and by the user can now ensure almost 100% reliability in producing sterile solutions.

Modern developments in pharmaceutical production, particularly the manufacture of sera, hormones, vitamins and anti-biotics, and similar preparations which are detrimentally affected by heat sterilisation have led to the rapid development and widespread use of porous porcelain filters as a production aid.

By reason of the fine pore size, 2.5μ and less, the rate of flow of solution is slow; recent developments have tended towards increasing the size of element, and thus gaining additional filtering area.

The elements used for this work are usually checked at the plants by the bubble pressure test, after each cleansing to check the maximum pore size. This is purely for control purposes, and to check the general condition of the element.



Diagrammatic section of air slide.

Another type of fine grade porous element is made from Kiesulguhr. Kiesulguhr filters have been used for many years for the filtration of drinking water in rural areas. They can also be used for the sterilisation of liquors, but in practice are not as reliable as the porcelain type elements. Their chief industrial application is in the preparation of soft drinks, where they are used to remove fine dusts and "bloom". Owing to the natural characteristics of the raw material, Kiesulguhr filters have exceptionally high flow rates for the pore size.

It would be difficult to mention the industries benefiting from the use of porous ceramic filters. Briefly, they are being widely used in the chemical industry where the resistance to corrosion is the main feature. They are becoming increasingly widely used in industries which need very fine filtration. The permanence of the filter media is being appreciated in the engineering industry, where increasing use is being made of the large sizes in which these elements are made.

The pharmaceutical and cosmetic industries provide ideal applications where it is desired to polish, i.e. remove bloom or haze from liquors, thus increasing the sales appeal of a product.

The engineering industries generally present more difficult problems. So far little progress has been made in the filtration of water soluble cutting oils, but where straight cutting oils are used, the removal of coarse particles from the coolant by means of a porous ceramic element has given improved surface finish. Under certain conditions, emulsions of oil and water will not filter as an emulsion, but separate to oil and water, thus immediately limiting the field of application.

For some years some continental machine tool manufacturers have fitted porous ceramic elements to the pipe line circuits to remove small particles of foreign matter from the oil. This to date has, however, had only limited application.

From this rapid survey it can be seen that the applications for this new engineering material are by no means exhausted.

Porous Ceramics in Diffusion

One of the earliest methods of improving the diffusion of a gas into a liquid was to drill a number of holes in the wall of the tube, through which was blown the gas. The decrease in size led to an increase in bubbling efficiency, and an increase in the rate of absorption of gas into liquor. The use of a porous ceramic diffuser decreases the bubble size and increases the overall efficiency. In the case of carbonating a soft drink, this is an extremely important point.

In certain processes where bacteria are grown under controlled conditions, the use of a porous ceramic diffuser element has greatly increased the efficiency of the operation. However, in other cases the bacteria have clogged the pores of the diffuser in a very short time, and led to the complete failure of the tube as an aerator or diffuser.

New methods of treating the diffusers have been devised which will eliminate many of the troubles due to bacteriological growth in the pores. But it is too early to say if these methods are fully effective.

The widespread use of ceramic diffusers is not fully appreciated by the layman. A common application is the diffusion of one liquid into another at a predetermined rate, usually one liquid being in very small quantities. A further device used for measuring the rate of variation of a gas pressure uses a porous ceramic disc. The advantages of using a porous ceramic for such an operation, compared with a plate with a single hole, can be appreciated when it is realised that a small particle of dirt would readily block a single orifice whilst it would hardly affect the flow through a porous ceramic disc.

Fluidised Conveyor or Air Slide

For many years it has been known that if air is allowed to diffuse through fine powder material or granular material, the powder may become "fluidised". The normal angle of repose of the material is altered until it acts as a liquid.

This property is used in a conveyor, commonly known as the air slide. Until recently the air slide was unknown outside the cement industry, but its

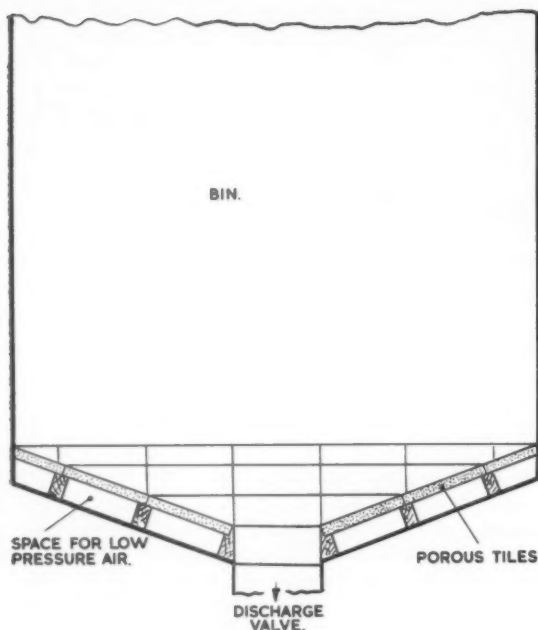


Diagram of storage bin fitted for air-assisted discharge.

use is now extending to others which have similar conveying problems.

The air slide consists essentially of a trough which is divided into two sections by a porous medium which may be either a porous ceramic tile or canvas. The upper section is the conveyor section, and the lower section is the air duct. Air is fed to the lower section and escapes through the porous medium and powder on it to atmosphere. The air passes through powder and produces the fluidised effect. The powder will then flow readily down a very shallow slope.

If the slide be mounted at a shallow angle the powder will flow readily along it. In the cement industry, powdered cement has been transported over considerable distances using the air slide.

The full capabilities of such conveyors are not yet fully apparent, but it seems certain that they will be widely used for the conveying of fine powders in future years.

One further development of this "fluidised" effect is in the fluidising of storage bins, and silos. Many powders have bad caking characteristics, and when stored in large bins and silos frequently 'bridge' and prevent powder being withdrawn from the bottom. In the past when this has occurred the bridging has been broken up by treating with rods or vibrators. Neither of these solutions has proved completely satisfactory, since the powder tends to pass from the bin in lumps.

These troubles have in many cases been overcome by the use of fluidising, thus preventing bridging and aggregation of the powder. The product is usually handled more readily from a fluidised silo than from a static silo fitted with a mechanical discharge.

The fluidising is achieved by placing porous tiles in the bottom of the silo and blowing air through them. The porous tiles diffuse the gas evenly over a large area, and prevent channelling through the powders. (Channelling frequently occurs if the air is blown through single jets.)

It must not be imagined that all powders can be handled in this manner, since each material has its own particular characteristics, but most fine materials have proven suitable.

In this Paper the author has attempted to give a general survey of the modern uses of porous ceramics, and has included those applications which are of greatest interest to the Production Engineer.

BRITISH PRODUCTIVITY COUNCIL

A pamphlet recently issued by the British Productivity Council describes in some detail its policy, programme and organisation, including the operation of Local Productivity Committees and the Council's Circuit Scheme.

Copies of the pamphlet, price sixpence, may be obtained from the Offices of the Council at 21, Tothill Street, London, S.W.1.

JOURNAL BINDERS

Members are advised that binding cases for the new size Journal are now available, and may be

ordered from the Head Office. The cases, which are strongly made and covered in dark red leather cloth, with "The Institution of Production Engineers Journal" in gilt on the spine, will each hold 12 copies of the Journal. The price per case is 10/-, post free.

CORRESPONDENCE

Written discussion on Papers published in the Journal, or correspondence on matters of interest to Production Engineers, is invited. Communications should be addressed to The Editor at 36, Portman Square, London, W.1.

THE SIR ALFRED HERBERT PAPER, 1953 REPORT AND DISCUSSION

A MEETING of the Institution of Production Engineers was held at the Sheldonian Theatre, Oxford, on Friday, 24th July, 1953, at 5.30 p.m., at which the 1953 Sir Alfred Herbert Paper, entitled "Industrial Applications of Radioactive Materials", was presented by the author, Sir John Cockcroft, K.C.B., C.B.E., M.I.E.E., F.R.S., Director of the Atomic Energy Research Establishment, Harwell. Mr. Walter C. Puckey, President of the Institution, was in the Chair.

The proceedings were opened by the Mayor of Oxford (Councillor A. B. Brown), who said that he was indeed honoured to welcome the Institution to Oxford, particularly on a day when Sir John Cockcroft was the lecturer. In Oxford they were in no doubt of the absolute importance of the work which the scientists were doing and, in particular, the work which was being done at Harwell.

There were times when some of them viewed with apprehension some of the manifestations of the activities at Harwell, beginning to wonder whether Oxford was going to be hemmed in on yet another side by yet another industry. But they knew the importance of industry and how much the city owed to it. They were truly delighted that a branch of the Institution had been started in Oxford and that already it was extremely flourishing.

After thanking the Mayor, the President said he was reminded of a visit paid to Oxford in 1668 by Samuel Pepys, who recorded in his diaries that Oxford was "a mighty fine place—a place of great comfort and cheap entertainment". The President was not sure whether he should use the word "cheap" in relation to Oxford—it might be misunderstood—but if they looked at a dictionary for a definition of the word "entertainment", they would find that it included hospitality and that it also included "a sense of well-being from listening to something which refreshes the brain". What they had had already and what they were going to have would give them both hospitality and refreshment for the brain, he suggested.

Tribute to Sir Alfred Herbert

The President felt that he should explain the purpose of the meeting for the benefit of the younger members and those present who were not members. They would notice that the Paper was called the 1953 Sir Alfred Herbert Paper, in accordance with the practice of the Institution to honour some of its distinguished members who had done good service for the Institution in the past by associating their names with authoritative Papers given by eminent personalities.

It was hardly necessary for the President to recall the name of Sir Alfred Herbert, which was very well-known in this country. Sir Alfred was a young man, 87 years of age, who lived in Coventry—or, rather, his works were in Coventry; and his name was known wherever Production Engineers lived, which was pretty well all over the world. He had been a great asset to the Institution and to British industry over many years, and the Institution were honoured that he had allowed them to associate his name with one of their annual named Papers. Sir Alfred had said that he would very much like to see the lectures have wider applications than those confined to the narrow aspects of the metal working industries or the machine tool industry with which his name was associated, and he had naturally been very pleased to hear the decision to select this year the subject of radioactive materials, as well as the name of the distinguished lecturer. Although Sir Alfred was unfortunately unable to attend, he would be particularly pleased to learn of the great reception given to the Paper, as indicated by the large attendance on a fine July afternoon.

A Distinguished Lecturer

Introducing the speaker, the President said that Sir John was very well known not only in this country but in all civilised countries. Nevertheless, again for the benefit of the very young members who might not realise his distinction, the President thought he should remind them of Sir John's career. He was educated at Todmorden Secondary School and studied mathematics at Manchester University. After serving in the First World War in the Royal Field Artillery, he returned to Manchester to study electrical engineering at the College of Technology under Miles Walker, another very well-known name. After two years' apprenticeship with Metropolitan-Vickers Electrical Company he went to St. John's College, Cambridge, and took the Mathematical Tripos in 1924. After this, he worked under Lord Rutherford in the Cavendish Laboratory.

In September, 1939, Sir John started work on the application of radar to coast and air defence problems. He went to Canada to take charge of the Canadian Atomic Energy project and in 1946 returned to England as Director of the Atomic Energy Research Establishment at Harwell. He had been honoured by many nations and the Institution, in turn, was honoured by his presence.

The subject on which he would talk was of very great importance to all Production Engineers. In the last few years the nation had been particularly

concerned with the application of science. It had been said by many people that there was only one thing wrong with the nation—our ability to produce. Perhaps we went too far sometimes in condemning the production achievements of industry because great things had been accomplished despite current criticisms. The President assured Sir John that one of the things which the Institution was anxious to accomplish more than anything else, was to associate itself to an even greater extent with new scientific developments and to make certain that they were applied speedily, energetically and skilfully to the

productive processes. Those who had already read the Paper would appreciate the tremendous practical possibilities offered by a study of radioactive materials. They were indebted to Sir John for the time he had given to the preparation of the Paper. They were deeply intrigued by the instruments standing around the microphone and they looked forward with the greatest interest to hearing Sir John read his Paper.

(Sir JOHN COCKCROFT then presented his Paper, which was published in the August, 1953, issue of the Journal).

DISCUSSION

Professor F. E. Simon (*Clarendon Laboratory, Oxford*), who opened the discussion, said they had heard the fascinating story of the application of radioactive materials in industry. This opened an enormous new field and no doubt one could think of other possible applications. The Professor mentioned the story of a man living in a boarding house who suspected that the left-overs from certain meals found their way into the Saturday pie. He took a little radioactive material and put it on his plate. On Saturday he brought along a Geiger counter and proved to his satisfaction and that of his fellow guests that his suspicions were fully justified. The introduction of such methods might be of assistance to those who lived in boarding houses!

It was surprising how small had been the expenditure in the field of radioactive isotopes in comparison with the results which were achieved through their application in industry. It would be interesting to find out how much money had been saved relative to the amount invested. Even that did not take account of the enormous amount of good-will which had been built up in other countries by the generous way in which Harwell supplied them with radioactive materials.

But although the effort was small in pounds, shillings and pence, that did not mean that it had been easy to create the organisation, and industry everywhere must be grateful to Sir John Cockcroft and his colleagues at Harwell for having done this so quickly and efficiently.

Professor Simon said he had one or two questions to put to Sir John. First, did industry make the best use of the new tool at its disposal or was it hampered by lack of highly skilled technologists? Secondly, Sir John had mentioned the use of radiation from radioactive materials for the production of new materials, such as plastics and the catalysing of chemical reactions. The Professor assumed that would also include the use of radiations now destroyed in the biological shields of the reactors. With the coming into use of

nuclear power stations, which by the end of the century might have a capacity equal to the present capacity of the British Electricity Authority, these amounts of radiation energy available would be enormous—thousands of megawatts—and its use might become very important indeed. Could Sir John tell them a little more on that point?

Sir John Cockcroft, in reply to the first question, said their experience was that it did not take very long to train a good technical assistant to use these materials.

Dr. Henry Seligman (*Isotopes Division, Harwell*), said progress was not held up so much by lack of technicians as by lack of knowledge that the methods existed and could contribute to production processes. An assistant or even a scientifically minded man could easily be trained in a relatively short time. The organisation trained such men in four weeks. They were then released back to industry to get on with their problems.

He was reinforced by Sir John Cockcroft, who said Higher National Certificate men could be trained in that way; that was the level of scientific education needed.

Dr. Seligman added that 200 people had been trained already in the Isotope School.

Sir John Cockcroft, referring to Prof. Simon's second question, said there would be very large amounts of radioactive materials which could be extracted from waste products, 100,000 times or even a million times stronger than a gramme of radium. Recently a general conference was held at Harwell with representatives of industry to give preliminary thought to how this could be used by chemical engineering and industries in the future. There seemed to be a possibility of using it in a big way for sterilising food and destroying bacteria in food. If these expected large sources were available they could treat large amounts of materials, quantities measuring in thousands of tons a year. There were possibilities of producing new chemical products by the effect of

radioactive materials on simple products, turning them into more complex products.

What they proposed to do at Harwell was to make a number of fairly powerful sources—such as 300 curie sources of radio cobalt—and lend them to the Universities and industry at a modest charge, to encourage them to experiment with different chemical reactions. There was such a width of possibilities to be investigated that they wanted the work spread over a much broader front than at present.

Mr. Burton Foringer (U.S.A.), who said he was working on electronics with the Armed Forces in this country, explained that his work was particularly connected with radar. The question which seemed important to him was the relative directivity of the electrons. Could they be directed in certain directions by a reflector or some other device which would allow them to be focussed on a point? Such directivity would be very important.

Sir John Cockcroft replied that they did not make use of directivity. It was possible to limit the divergence of a beam of electrons by putting a diaphragm in the path but, in general, they did not focus electrons. The instrument which he had demonstrated for measuring the thickness of a pipe made use of an ingenious electronic device which might be of interest to the questioner. Electrons scattered back from the wall lost energy and were considerably lower in energy than the electrons when they went into the pipe. The gadget on demonstration looked for electrons which had lost energy and counted them.

Mr. A. O'B Brandon (*Chief Engineer, Refrigeration Division, The Pressed Steel Company*) said that as the first industrial speaker in the discussion, it fell to him to say how ignorant most of them were of the potentialities of the radioactive materials which Sir John had explained so well. He, in particular, felt ashamed that although he lived in Oxford, so near Harwell, he had not long ago taken advantage of these possibilities in their research work. They had often considered these applications in specific problems and had always turned them down, because they thought they saw reasons why these applications could not be used. As far as he was concerned, that attitude would not persist in the future.

One of the problems in which they had considered the use of the new techniques was in leak detecting, although rather a different kind of leak detection from that described by Sir John. He hoped they would find some help with this problem in the future. They had to detect the loss of refrigerants from systems which had to be guaranteed for rather a long time, and they were using methods which would detect a leak as small as one ounce of refrigerant in 20 years. Since they had only a very short time on the production line in which to make the test and check,

it meant that they must be capable in 10 seconds of detecting a leak as small as 10^{-7} grammes.

Mr. Brandon said they had considered, as a more sensitive method, the use of radioactive materials in the gas. It would be particularly advantageous because the method they were using at the moment tended to measure other things within 100 yards. That was extremely embarrassing and they had a large ventilating plant to bring air from outside the factory so as to avoid this difficulty. The reason they had not used radioactive materials was that they thought the metal of the tubes would not keep in the active particles or bricks so that they would detect the gas in the system as easily as they detected the leak. Perhaps Sir John could deal with that point and say whether the method could be used.

Another problem of interest was that they had a lot of materials inside the refrigerator cabinet which contained volatiles—rubber and things of that kind. These volatiles could occasionally be embarrassing for they caused very minute taints in foodstuffs. There was a very sensitive test for that. It was sometimes desirable to know which materials inside the refrigerator were causing the trouble, and they felt that it might be possible to use radioactive constituents in some of these volatiles so as to locate those which were responsible.

A much more intriguing problem was one which had worried a great many of them from a research point of view. It was that of being able to measure the flow of refrigerants in pipes. That problem was quite different from any which had been described during the lecture. It was easy enough to measure the flow of a liquid, but it was a more difficult problem with a refrigerant, which was a volatile liquid varying in density, to know the exact weight flow, which was much more important.

With certain refrigerants and certain other compounds another problem arose. Oil was completely soluble in these refrigerants so that one did not know what proportion was refrigerant and what proportion was oil. It would be difficult to make an analysis to find out. If it were possible to use radio active elements in the refrigerant and detect the rate at which they were passing a certain point, knowing their concentration, it might be possible to have an absolute measure of the flow of the refrigerant in terms of weight and it would not matter whether they measured as a vapour or as a liquid.

Those were three problems on which he would certainly seek Sir John's guidance.

From the Paper, Mr. Brandon had found that even the people who made nylon had difficulty because it got dirty. Those people who travelled a good deal had formed the habit of buying nylon shirts, which could be washed in a hotel bedroom. They now hoped for the production of a radioactive detergent, so that they could very easily get rid of the nasty black dirt which collected particularly on the shirt cuff!

Sir John Cockcroft, in reply, said it was probably possible to detect the leaks of the fluid used in refrigerants and also possible to incorporate radioactive material, such as sulphur, in the rubbers used in the refrigerator, thus detecting and checking any transfer of the material outside the body of the refrigerator. Dr. Seligman could say whether the problems had been investigated. The third problem was rather more difficult and it was difficult to see a solution.

Dr. Seligman told Mr. Brandon that some time ago one of his competitors had approached them on the first problem mentioned and Mr. Jefferson, of the Isotopes Division, had looked into it in some detail. He discovered that it was not a project they could use on the production line for quite a number of reasons. First, they had to have too much radioactive material about the factory. The other problems mentioned, especially the last, were intriguing, but they could be tackled. Perhaps Mr. Jefferson could give his views on them as he had done some experiments.

Mr. Jefferson (*Isotopes Division, Harwell*) said it was possible to use radioactive material inside a system which, in the absence of leaks, would not show at all. The metal walls were quite adequate to stop all activity. The only thing one had to work out was the quantities involved. In this case it meant having rather too much activity in the liquid. Only a very minute mass of material needed to leak out to constitute a rejection leak, which necessitated the high activity.

They had looked at the problem where the liquid changed its nature—from the gas to the liquid phase and back again. If the refrigerant were in its liquid phase the problem was quite easy, for it was easy to inject small quantities of radioactive material at regular intervals, or one or two quantities at longer intervals, and study the dispersion or movement of the liquid they put in. If the liquid were to change to the gas stage, however, it would be necessary for the materials to have the same chemical identity; the atoms which were radioactive would have to be part of the atoms forming the liquid, and they would then continue to form part of the atoms in the gas stage.

Dr. N. Kurti (*The Clarendon Laboratory, Oxford*) said they had heard a very impressive survey of the various uses of radioactive materials. He wanted to know whether there was a danger of these materials being used simply because of the novelty and the glamour attached to radioactive materials, when more usual methods were equally efficient. Even the very ingenious method of testing the food at boarding houses, mentioned by Prof. Simon, could have been equalled fifty years ago by a chemist adding a small quantity of strontium chloride to the left-overs on Monday. Saturday's pie would have coloured a flame a brilliant red!

Sir John Cockcroft agreed that the glamour of any new methods attracted many new inquiries, but he thought that the continued use in industry of

these methods would depend on hard economic facts. The question would be whether they saved their organisation money in carrying out the process or whether they could do a job in research which otherwise could not be done. The glamour would fade automatically.

Dr. Seligman added that they frequently discouraged production people from using radioactive materials if the job could more easily be done by different methods. Recently they had discouraged a toy manufacturer from using radioactive materials in producing toys for children, their object being to protect the children. The manufacturer went away quite happy about it. It was not only the glamour which was considered.

Mr. W. A. Sales, O.B.E. (*Director of Aircraft Production Development, Ministry of Supply*) said his main interest in life was to see that the utmost use was made of anything new which appeared in view on the horizon. Sir John had shown them a lot of new things of which the engineering industry could make a great deal of use. It was principally on that basis that he wished to speak.

The valuable Paper illustrated the great benefits to be derived from a "get-together" of men in different fields of science and engineering. There was no need to comment on the most excellent examples of applications of radioactive isotopes to industrial problems quoted by Sir John except in terms of praise, for they spoke admirably for themselves. Viewed in retrospect, the advances in radiography derived from the use of this variety of radioactive material, easily transportable to the site and embodying a wide range of penetrating values, might not at first sight appear to be the outstanding achievement which in fact it was, and that was largely because they were accustomed to look only at their own individual problems of radiography. Collectively, however, it represented a tremendous advance for which they in engineering must be eternally grateful. That, of course, was only one example of the many achievements quoted.

The Paper also illustrated the wisdom of consulting with the "other man" as well as taking a close interest in his work. At first sight there might not appear to be much in common between the engineer and the atomic scientist, but a little reflection would show that the latter was already well on the way to becoming the engineer of the future, although he was certainly using much smaller bricks than those to which the ordinary engineer was accustomed, and degrees of precision which seemed to them "out of this world". Since steel could now be rolled to a thickness of .000085 ins. they could see the need for introducing some new measuring apparatus. The old methods were getting out of date.

Mr. Sales said he could not help feeling that the man who was prepared to share the interests of his own trade or profession with those of another could often, with his particular pair of spectacles, see uses

for the other man's development hitherto unsuspected. It was in that respect that they should encourage all to look at the problems. In other words, now that Sir John had devoted his time to this particular subject, they should not, as it were, wait for the atomic scientist to solve problems of theirs which he had never heard about. They should at least bring those problems to his notice for treatment, together with any ideas or suggestions which they themselves might be able to make to contribute to a possible solution. To show the close connection between the engineer and the atomic scientist, it was interesting to observe that problems of a purely engineering character were arising in the atomic scientist's day-to-day work. Mr. Sales said he had visited Harwell and he could say that such problems had not only been successfully cleared, but new techniques of manufacture had in some cases been evolved at the same time. Work in the field of clad metals—in some cases metals with forged properties made direct from powders—was a good example.

While they had confessed to the high value of the advances in the technique of radiography previously mentioned, on the principle of *Oliver Twist* they were hoping that eventually the atomic scientist would evolve a method of detecting a state of strain or inter-molecular attenuation, such as shrink strain in cast structures as opposed to complete rupture such as crack, blowhole and other ruptures. Such instrumentation would be of extreme value. By revealing locked-up stresses in forgings, which tended to rob them of half the natural strength of the material, or hot tearing in the case of castings, it would show the weaknesses in their present manufacturing techniques and would enable them to trace back through the process and probably find out what was wrong. Something of that character would be of considerable value to the aircraft man in research and development. He could then define exactly what was happening at different parts of the structure instead of having to rely on strain gauges, which were often difficult to apply.

There were many other problems awaiting solution, and they must be presented in the hope that they could be solved by the atomic scientist. They all appreciated the value of any atomic process which displaced the human inspector; they all knew of the case of the chap who "once let us down". After all, the human inspector tired.

Sir John Cockcroft said it was difficult to deal with the problems of strain by nuclear methods, although atomic particles could be used to show the state of crystallisation of materials.

Dr. Seligman said they had had the honour of seeing Mr. Sales at Harwell and a good part of a day was spent in discussing those and similar problems, but they had reached the conclusion that for the time being they did not think it worthwhile to put their money on the work. Times might change, of course, but for the time being the answer was "No".

Mr. C. C. Bates (*Chief Welding Engineer, Costain-John Brown, Ltd.*) said that he was particularly interested in the reference, in Sir John's Paper, to the use of radioactive isotopes in New Zealand and their transit out there. His Company had been using them for three and a half to four years and had occasion to send them out to the Middle East, but the problem they experienced was that if they sent out a sufficiently strong source, the aircraft company would not carry it unless it was very heavily protected, necessitating very heavy containers.

On the other hand, if they sent out cobalt sources they did not do for the particular job as well as iridium 192. Cobalt, as Sir John knew, was quite a harsh source and consequently on thin material, such as a pipeline, did not produce an entirely satisfactory radiograph. Mr. Bates wished to know from Sir John and his colleagues how they overcame the difficulty of sending out sources such a long way, particularly sources which had a comparatively short half-life.

Sir John had also mentioned in the Paper the use of radioactive phosphorus and developed films. Mr. Bates could not see that this method had any advantage over the ordinary magnetic crack detection equipment and asked for some enlightenment on the advantage of using a radioactive source in this instance.

There was also in the Paper an illustration of a radioactive source being used on a pipe. He took it that the source was being inserted into the pipe, in which case it was good practice to have the source about 9 ins. from the pipe wall, thus giving an approximate 18 ins. diameter pipe. The pipe in the illustration did not appear to be 18 ins. in diameter, and he wondered whether Sir John had any comments?

Dr. Seligman replied that it was true that the transport of isotopes was limited to some extent by the need for big containers, but they overcame that by using wing-tip containers for sending isotopes abroad, so that the shielding was by distance by the inverse square law. Until recently they had not been able to ship iridium in reasonable quantities, but they overcame this difficulty by enclosing it in a very small lead ball.

Dr. Seligman thought Mr. Bates' question about pipes and the use of harsh sources depended on the thickness of the pipe. When he was told by Mr. Bates that it was half-an-inch, he replied that iridium would be the right material.

He agreed that the use of magnetic fields and methods, as suggested by the questioner, was satisfactory, but the radiographic method was very quick and had the advantage that a record was available afterwards.

Mr. M. Seaman (*Director and General Manager, British Oxygen Engineering Co. Ltd., and Chairman of the Institution's Editorial Committee*), said he

wanted first to comment on the distinguished lecturer, because in his experience he had seen the circle of events come to their full closure. In 1922, as a student of Miles Walker, and at Metropolitan-Vickers, Sir John was very much a Production Engineer in the electrical sense, just as members of the Institution were Production Engineers in the general sense.

Following Sir John's work at Metropolitan-Vickers and Manchester, Mr. Seaman always had the feeling that it was his work in producing constantly higher voltages for the Rutherford team which led to so much advance in that direction. Since that time there had been great progress in that field, until Sir John had come to a body of practising production technicians and given them a complete field of instruments and techniques, the length of which would not be found in the next fifty years. They were only at the beginning.

It was in consideration of that technique that a general comment was advisable, in line with something Professor Simon had said about the number of trained technologists to be available purely for applications. What they had had demonstrated was an enormous advance in the tools. Mr. Seaman had been reflecting on this and discussing it with a distinguished physician, asking him about X-ray and the use of isotopes in connection with the human body. He had been surprised to hear that the static X-ray tube had in fifty years only advanced to a degree at which they were getting the necessary discrimination by chemical methods on the film. The X-ray had been a comparatively inflexible tool for the Production Engineer but isotopes, both as tracers in the evolution of mechanisms and in production processes, were an enormous advance, of which Sir John had given innumerable examples. This flexibility was of great importance in production economics.

It was within the knowledge of most of them that many production processes were inefficient because of the limitations of knowledge and techniques. It was true that there was a constant need for tools by which the practice of the Production Engineer could overleap the lack of knowledge of the designer to produce cheaper and better designs. In the lecture and the discussion they had had a whole map of methods which he was sure would be of first-class importance in this century. One could answer Professor Simon's question in this way: quite apart from the number of technologists we required to operate the controls and to use the means which were provided, the actual technique was being built up at Harwell with industry and its formation would be at a very high rate in the next fifteen years.

Mr. Seaman turned to some technical points in which he was interested. One concerned the techniques of metal manufacturers, in steel casting in particular. During the war the aircraft industry required castings of very high uniformity of strength. They were using the relatively clumsy X-ray methods

up to 400 kV. He was interested in the use of fluoroscopic methods for rapid examination. He knew of one case where continuous fluoroscopic examination was used for light alloy testings and, as an inspection method, was saving many hours of wasted production time. They had been shown that a series of isotopes which could discriminate with sensitivity and could be conveniently applied might be introduced, using fluoroscopic methods, providing constant and effective inspection methods and saving time and material. That may have been dealt with elsewhere but it was not in the Paper, and Mr. Seaman suggested that some note of it should be included in the discussion.

Another startling thing was the possible use of radioactive tracers after the pouring point of metal to study shrinkage properties, strain and thermal properties of the resultant metals. Mr. Seaman said he had always been astounded to hear that it was possible for such tracers to exist through the melting and processing of steel to solidity. If that were possible, it was another direction in which a very valuable tool was placed in the hands of the metal producers. It should be of great value in the production economy. Mr. Seaman said he saluted Sir John on having brought, as a practical man to a very grateful body of practical men, an enormous field of techniques and processes.

After **Sir John Cockcroft** had suggested that the continuous method of radiography suggested by Mr. Seaman should be possible in principle, **Dr. Seligman** added that the Canadians were in the lucky position of having a stronger nuclear reactor and had tackled the problem of using stronger radioactive sources. They used iridium and made fluoroscopic pictures, but the result was not quite good enough, the intensity not being sufficiently high. He thought that in a short time—five or ten years—they would have reactors to produce radioactive sources which could be used for this purpose. It was only a matter of intensity. Some investigations had been made into the other problem which Mr. Seaman had raised and Mr. Jefferson would explain them.

Mr. Jefferson said the investigations to which Dr. Seligman had referred were into the continuous casting of aluminium. The people concerned wished to know the delineation of the solidification line. They were quite confident that this could be achieved by adding a radioactive tracer to a small quantity of molten metal which would be added to the main flow in the casting process. That section would be cut along its axis and a slice taken and used for a radiograph study of the material at the solidification boundary. One point which was not completely obvious about radioactive isotopes was that they were completely unaffected by temperature or pressure or anything else, as long as the atoms retained their identity.

Mr. I. S. Morton (*Product Development and Research Department, Shell Petroleum Co. Ltd.*) said he had listened with great pleasure to Sir John's

review and was particularly interested in his reference to the use of a radioactive piston ring in lubrication and wear studies, since they had made extensive use of such methods at Thornton Research Centre during the last few years. As remarked in the Paper, the sensitivity of measurement enabled results to be obtained in a relatively short time, but in the case of engine tests there was another important advantage. In older methods of studying engine wear it was necessary to strip the engine periodically for examination, bore measurement or weighing of rings, etc. However carefully the engine was re-assembled, it could never be restored exactly to its former conditions, and while the engine was settling down again there was inevitably some additional wear of a running-in nature which would not have occurred in the undisturbed engine. With the radioactive method it was possible to obtain reliable wear estimates by periodical examination of lubricating oil samples for radioactive iron without stopping the engine. The results obtained could be taken with confidence as representative of the course of wear and the method had proved to be a great advance from which invaluable results had already been obtained.

Details had recently been given in a Paper by Dyson and Williams to the Institute of Petroleum—"The Use of Radioactive Tracer Technique in the Wear Test of Engine Lubricating Oils"⁽¹⁾—and it was hoped to give a public demonstration of the equipment later in the year.

An earlier application of tracer techniques at Thornton was first described some time ago—Button, Davies and Tourret: "Study of Tracer Methods for Assessing the Wear of Wire Drawing Dies"⁽²⁾. Since it concerned a production process it might be of interest to the meeting. The authors wished to investigate friction, lubrication and wear in wire drawing and the tungsten carbide die seemed particularly suitable for this kind of approach, since its constituents formed suitable radioactive isotopes under neutron bombardment. The die was sent to Harwell for irradiation before each series of tests and then, with appropriate precautions, delivered to Thornton and installed in the wire-drawing rig. This apparatus was a vertical form of draw bench in which six foot lengths of copper wire could be drawn at speeds up to 600 f.p.m.

During the drawing process, wear products from the die were deposited on the wire and various methods of measuring this were tried. Auto-radiographic detection of wear debris was first used on grounds of simplicity, and different types of wear were clearly detected. For instance, fairly uniform wear deposits were found and attributed to cobalt eroded from the drawing taper and bearing portions of the die by the polishing action of the wire. There were also discrete deposits occurring irregularly either as individual spots or non-uniform groups, and these were believed to be carbide particles plucked from the ring region. This method gave a qualitative rather than a quantitative measure of wear, though it was possible to estimate that the wear rate

was about 2×10^{-8} gm. per foot, which compared well with figures based on field practice.

To obtain figures of the significance required for comparisons of lubricants and so on, it was necessary to integrate the wear over longer lengths of wire, and the method finally adopted was to form a closely wound helix from each six foot length and assay it by placing it around a thin-walled Geiger-Müller counter. In some comprehensive tests a large number of wires was drawn and it was found that the rate of wear had a distinct quasi-cyclic variation, the maximum rate being about three times the minimum. This rather remarkable feature had made it difficult to correlate the results of brief laboratory tests with field experience, but this was due to the complexity of the wear process itself and not to any shortcomings of the measuring technique. The technique had, in fact, been able to detect for the first time the minute wear deposits on the drawn wire from a tungsten carbide die, and the usefulness of the tests seemed rather to lie in the investigation of the fundamental processes of die wear. Thus, apart from the results already quoted, it had been possible to show that within the range of speeds used, the type of wear was not influenced by speed.

As far as they were aware, radioactive methods had not yet been used in this country for the study of cutting tool wear, but a Paper had recently been published describing work of this kind in the U.S.A.⁽³⁾ Ernst, Merchant and Krabacher had given an account of work in which a radioactive lathe tool was used and the chips produced collected and measured for radioactivity. In the work described, some interesting curves had been obtained, indicating a rather surprising uniformity of rate of wear with time, and examples were given of practical results derived from such tests. These included investigations of the machining properties of various work-piece materials and comparisons of the performance of different cutting fluids. The work had also contributed to the fundamental study of the metal cutting process, and Mr. Morton was particularly interested in an auto-radiograph of a chip showing uniform distribution of wear produced along the chip surface and making an interesting contrast with the discontinuous and varying incidence of wear in their wire drawing experiments.

(References:

1. *Symposium on Engine Testing of Lubricating Oils*, 22nd April, 1953.
2. *Isotope Techniques Conference, Oxford, July, 1951*, Vol. 2, 34; and "Nucleonics", 9 (5), 34, November, 1951.
3. *Trans. A.S.M.E.*, 75 (4), 549, 1953.)

Mr. B. H. Dyson (*Director and General Works Manager, Hoover Ltd., and Vice-Chairman of the Institution's Research Committee*) congratulated Sir John on a very refreshing Paper. To be frank, his personal reaction was that it had whetted a rather lazy appetite for what had at first sight appeared rather an unpalatable meal. The person who provided the stimulating aperitif of the Sheldonian

Theatre probably thought he had to do that in order to whet the real appetite, but there was no question about it—after reading the Paper, which he had done three times, Mr. Dyson had realised it to be a brilliant analysis and one which even he could digest.

In contributing to the discussion, Mr. Dyson had a certain personal satisfaction, for some little time ago his Company's engineers had been able to reverse the process somewhat by supplying Sir John's establishment with an industrial appliance to aid in the production of radioactive materials.

It appeared that one of the immediate industrial applications of radioactive materials was to maintain and improve the quality of industrial products, with particular reference to the thickness of materials and surface finishes. Productivity had been mentioned, and undoubtedly one of the things for which the overseas markets were asking was a return to good quality British products. He had always been convinced that it was impossible to inspect quality into a job. It was only by processes which gave a continuous automatic check while the production process was going on that industry had an opportunity to maintain a consistent quality. Sir John had been wise to stress, in his explanation of industrial applications, the maintenance of consistent quality.

Mr. Dyson asked whether the tests were applicable to paint and enamel coatings and whether the method could be used to detect rust or contamination under enamel. Could Sir John give any indication of the application of these non-destructive tests to spot and seam welding on a productive basis? A most important feature of the applications in industry was that they were non-destructive tests. The previous speaker had said it took fifteen minutes to get results, but in Mr. Dyson's type of work many products would be produced in that time.

Recently he had visited a factory manufacturing a Ministry of Supply fuse assembly and had been disappointed to find that the C.I.A. inspection authority used about twice as much labour in looking at the parts as they used in assembling, and these people were largely employed in virtually dis-assembling the product in order to see if all the bits and pieces were there. The application of package checking as illustrated in the Paper might be applied by the Ministry's inspectorate with advantage, in order to increase productivity and also to ensure a consistent quality.

Was it the cost or lack of portability of the equipment which prevented its use or the fact that the other side of the Ministry had not heard of what Sir John was doing?

Mr. Dyson said he was interested by the illustration of the testing of friction and lubrication, which led him to ask a question about determining and recording out of balance in high-speed revolving mechanisms. This might be a wide question, but was it possible to use the application to indicate out of balance in high-speed rotating mechanisms?

Sir John had not dealt to any extent with what Mr. Dyson considered the number one priority for the use of atomic energy—atomic energy as a basic source of power to replace coal and oil. In Connecticut they were laying down the hulls of the first two atomic-powered submarines. When we realised that the whole of the British Fleet and the Air Force was kept on the sea and in the air by imported oil, this appeared to be a number one job. In frequent opportunities to compare the productivity in America with that in England, he was coming to the conclusion that the fundamental advantage underlying the higher American productivity was the easily accessible and abundant supplies of coal, natural gas and oil. When we compared these with our thin seams of coal, often going under the sea so that direct approach was not possible, and our lack of natural gas and oil, atomic energy was perhaps our main hope to reverse the order of productivity between the U.S.A. and Great Britain.

How far away did Sir John consider the application of atomic energy to power stations and industry to be?

Sir John had done a grand job of work. His Paper referred to the existence of an Industrial Applications Group at Harwell, and it was up to Production Engineers to make use of the valuable assistance which Sir John's department could offer them.

Sir John Cockcroft replied that it had been announced two months ago that the first new nuclear power station was to be built in Cumberland.

Dr. Seligman said that as he was not as high in the ranks of the Ministry of Supply as Sir John, he could speak more freely! It was not his task to defend the Ministry, but he pointed out that they had installed thickness gauges and package monitors in some of their factories. They had some package monitors, for example, to check cartridges. They were not as far behind as had been suggested; some people in the Ministry had heard of Harwell!

The detection of rust under enamel was a tricky problem, although there was a chance of detecting it. It was a research problem and it depended very much on the density of the rust. It might be possible.

It was unlikely that present methods could measure thin oil films on rapidly moving parts, even if they were adapted, but other methods might be found of doing the job. Detection in spot welding might be possible but would depend on the time within which the results were wanted.

The **President**, summing up the discussion, assured members that the aircraft side of the Ministry of Supply at least knew where Harwell was! He could not hope to cover in his summing up all the points in such a wide discussion. When they realised the enormous range of problems which had been dealt with at Harwell in its short life, they could appreciate the reason for the device which detected the loss of even a single tablet of aspirin; no doubt that came about because there had been so many headaches at Harwell!

One of the key points which Production Engineers should carry away with them was the value of consulting the other man. They could see the value of the engineer going out to find men who could show him new things entirely beyond his present experience. There was no Production Engineer who could leave the Meeting without gratitude for the many opportunities he had been given of going back to put into practice some of the things he had seen. This was a great opportunity for closing the gap which undoubtedly existed in this country between the Research Engineer and the Production Engineer, who had to turn the dreams into reality. They were grateful to Sir John for this opportunity to lessen the gap between those two essential members of society; the meeting had given them such an opportunity and it had been well worth while.

When Dr. Seligman was asked why there was not a greater application in industry of some of these ideas and techniques, he said it was due to lack of knowledge and not lack of interest. The President said he would like to feel that industry had that interest. In his view, the attendance at the meeting showed that the interest existed. Many thousands who later read the Paper would realise what they had missed in not being present, and how much they would have to study this tremendous new tool for Production Engineers. The meeting had been worth while because it had shown the wonderful new tool at their disposal. The President was proud that the Institution had been able to provide a platform for a wider discussion of this information and for its wider dissemination, and they were grateful to Sir John and his colleagues for putting such detailed knowledge before them.

The President said he was reminded of how many inventions were designed for war and the killing of mankind, but in the long run had been devoted to the betterment of mankind. For many years dynamite was an agent of war, but today it was used in many civil operations, perhaps the first of which was that of the well-known researcher, Guy Fawkes. Radar had a tremendous impact on winning the war, yet today we saw it in television and there was no doubt of its contribution to safety in the air and on the sea. Antibiotics, which today were used to improve the health of mankind, were originally produced to deal with the battle injuries of the last two wars. Atomic energy, which was associated by so many people with war and destruction, was now coming into its own in the fields of peace. The

President said he was reminded of the words of a distinguished American:

"No one who has witnessed the awesome terrible grandeur of an atomic explosion can doubt for a moment but that this primordial force, under adequate control, has a nobler, finer destiny as a worthy peacetime servant for the welfare of all mankind."

The Institution was grateful to the Vice-Chancellor of Oxford University and to the Curators of the Sheldonian Theatre for allowing them the facilities of the Theatre. There had been many distinguished gatherings in that great hall, but probably very few which had such long-term significance for the future of British industry.

Major-General K. C. Appleyard, C.B.E. (*Past President of the Institution*) in proposing a vote of thanks, said he had a personal reason for doing so. Twenty-one years ago, when he asked his small son, aged nine, what he wanted to be, the answer was, "A research physicist". The boy added, "You took me round the research department of Metropolitan-Vickers and I have a good idea what a research physicist is". In due course, having arrived at Cambridge, he announced his intention to be a research nuclear physicist. Having achieved a room in the Cavendish which Kapitza used for so long, and having spent some time there, he said he wanted to move. This was a new field which might change the world, he said, and he did not know where it would lead him; he would finish up a poor scientist but would have had a lot of fun. From there he went to cancer research and to New Haven and elsewhere—and finally to Chalk River, which Sir John knew well.

General Appleyard had followed his son to America and elsewhere and had always been asked whether he knew Sir John Cockcroft. He was always told that Sir John was one of the great figures of the world of nuclear physics. Under his guidance, he was told, this country was leading the world. The Institution and the whole nation were grateful to Sir John and his team at Harwell for laying the foundations of a completely unknown future for their sons and grandsons. Where it would lead, nobody knew. The Institution had been uniquely honoured by having such a distinguished man to address them and they were grateful to Sir John and the team which supported him.

The Meeting then terminated.

COMMUNICATIONS

Some further questions submitted after the Meeting have been dealt with by the Isotopes Division at Harwell, as follows:

From: Mr. D. Jones (*Smiths Motor Accessories, Ltd.*).

In what way can radioactive materials be used in the balancing of mechanisms rotating at high speed?

Reply: Gamma radiography could be used to check alignment and departures from alignment in enclosed rotating systems, such as shafts and ball races. Tracer methods, coupled with autoradiography of surfaces, can be used to find the distribution of worn and transferred material in bearings and journals. Further tests on uses of radioactive materials to measure strain in rotating systems are

in progress, but a full account of these must await the completion of our experiments. Problems of this kind are generally solved more easily by excessive electronic apparatus.

From: Mr. B. G. L. Jackman (*Works Director, British Heat-Resisting Glass Co. Ltd.*).

Would it be possible to use radioactive silica or sodium constituents in a glass batch, melted in 100-ton furnaces at 1600°C, with a view to tracing convection currents as the glass melts and flows through from the point of charging to the point of glassmaking?

The dimension of the furnace comprises a tank of glass approximately 20 feet wide by 30 feet long, with a depth of 30 inches. If this unit is too large to monitor satisfactorily, what is the maximum size of tank which could be satisfactorily monitored in three dimensions?

The materials going into the glass at present are sand, pyrobor (dehydrated borax), alumina, sodium nitrate and boric acid.

Reply: Silicon has no radioactive isotopes with half-life greater than 170 minutes and would, therefore, probably decay too quickly for such an investigation. Sodium has a convenient isotope (Sodium 24), with a half-life of 15 hours, which emits beta particles and penetrating gamma rays. Sodium 24 thus has the advantage that its activity would quickly decay away after the measurement. This could be introduced by irradiating sodium carbonate in the pile and afterwards converting it to the nitrate.

The normal concentration of sodium used for mixing experiments is about one millicurie per ton of material, but owing to the absorption of the radiations in the glass of the furnace, about ten times this specific activity is likely to be needed for measurements to a depth of 18 inches. This would indicate an activity up to one curie to be used in a 100-ton furnace, which might be dangerous to personnel. On the other hand, if the radioactive constituents added were not fully mixed, much smaller total activities might be used.

The main difficulty in measurements would be to assess the distribution in depth of the furnace, but some information might be obtained by using detectors above and below the tank of glass.

Detectors would have to be water-cooled to operate close to the hot glass. Suitable detectors have been developed by C. H. Lewis for measurements in the combustion chambers of coal and coke retorts (Institution of Gas Engineers, Communications No. 394, 27th and 28th November, 1951).

(The Industrial Applications Group at Harwell would be pleased to discuss the problem in more detail.)

From: Mr. L. R. Beesley (*Director of Engine Production, Ministry of Supply*).

(1) Can the method of crack detection, as used on propellers at The de Havilland Aircraft Company, be applied to fine surface cracks on

internal surfaces and can a permanent photograph of the imperfections be obtained?

- (2) Is it possible to apply radioactive materials for checking the material thickness of spot or seam welded areas that are not readily accessible to normal means of measurement?
- (3) In the field of gas turbine research and manufacture, is it possible (a) to use isotopes for the checking of the quantity and variation of cooling air flow? (b) would it be possible to check the leakage of hot exhaust gas within the engine test cell? (c) is it possible to examine, with the use of isotopes, the peculiarities of air flow through the compressor of the gas turbine when it is suffering from the phenomenon known as "surging"?
- (4) The use of radioactive material for the X-ray of a single portion of difficult, large and complicated castings or fabricated components is most attractive to industry, but the Paper does not make clear the economics of the use of these materials. Can some indication be given of the cost of radioactive elements for various materials with a detailed statement of their life and also, when life expires, the cost of renewing their radioactivity?
- (5) The Paper indicates that chemical reactions of gases may perhaps be encouraged by (cobalt) radiations without recourse to high temperatures. Is it considered that chemical reactions between fused solids may be more readily achieved and controlled by the application of radioactive elements? Such chemical reactions are quite often a delicate manufacturing process.

Reply:

(1) The radioactive method of crack detection can be applied to fine surface cracks on internal surfaces to provide a permanent photograph of the imperfections. The ease or difficulty with which this can be done will depend very largely on the regularity of the surfaces to be inspected. If these are such that an X-ray film can be pressed into intimate contact with the surfaces, the method should not be very difficult. If the surfaces are very irregular, however, it might be necessary to use a strippable emulsion on the surfaces and the eventual value of the method would be rather doubtful. I should like to draw your attention also to the contamination which inevitably occurs even on perfect surfaces when placed in contact with radioactive material. It would be necessary to develop a very efficient means of cleaning these surfaces before using the photographic film, otherwise background fog from contamination would be likely to mask the effects of small cracks. The method has not been fully developed at Harwell, but only the principles investigated. A good deal of work is likely to be necessary before it could be put to routine use.

(Concluded on page 464)

ORGANISATION AND SUBSIDIARY ACTIVITIES OF THE INDIAN MINTS

by Major D. V. DEANE, C.I.E., O.B.E., R.E. (Retd).

Master of the Mint, Bombay

Presented to the Bombay Section of the Institution, 23rd May, 1952.

MY former colleague, Major Partridge, who has recently retired from the Calcutta Mint, read a Paper about 18 months ago to your Calcutta Section entitled 'The Mass Production of Coins'. This dealt exclusively with the details of actual coinage production, and I expect that most of you will yourselves have since read it, as it was published in your Journal.* When, therefore, I was asked to prepare a Paper on similar lines to read to you this evening, I felt that in order to avoid the inevitable repetition that would occur if I dealt with the same aspects of the Mints' activities as Major Partridge did, it would be more interesting to you to be given a brief account of the recent history and present organisation of the Indian Mints, and to tell you about some of our subsidiary activities, which are considerably more varied than is generally realised, and on which nearly 50% of our employees are engaged. Some of you will also be visiting the Mint shortly, and the actual processes of coinage can more easily and simply be understood whilst touring the departments, than by reading to you a number of statistical details. I have therefore prepared this Paper accordingly.

History and Development

Prior to the 19th century, a number of crude local Mints were in existence throughout India. The rapid growth of the power of the East India Company during that century, by the end of which it was in control of the greater part of the sub-continent, led to the demand for a common coinage of modern type to be introduced throughout the country. Accordingly, the construction of two new Mints, equipped with power-driven coinage machinery which had recently been invented by Boulton and Watt, was commenced simultaneously in Bombay and Calcutta in 1824 and 1825, and these Mints commenced production in 1828 and 1829 respectively. The other local Mints thereafter gradually suspended (or were compelled to suspend) their operations, until in 1947 there was only one fully equipped Mint in India which was not under the direct control of the Government of India. This was the Nizam's private Mint in Hyderabad, which State had continued to manufacture its own distinctive coinage throughout the period. After the accession of Hyderabad State to the Republic of India in 1948, this Mint came under the control of the Central Government, and is now operating as a branch of the Bombay Mint.

For some years before the Second World War, a proposal to move the Calcutta Mint from its congested and unsuitable site in the heart of the city had been considered and in 1940, due to the rapid expansion in the demand for coins during the War years, it was decided to build a new Mint on the outskirts of Calcutta on a convenient site that had been located and leased from the Port Commissioners. Orders for the necessary plant and equipment were placed, and work on the foundations of the new Mint was started during 1941. Early in 1942 the rapid advance of the Japanese armies through Malaya and Burma caused a serious threat of invasion to Eastern India, and it was decided to suspend forthwith all further work on the new Mint for the duration of hostilities, and meanwhile to construct a smaller temporary Mint in a safe area, in which the newly arrived plant and machinery could be installed and operated. Lahore was finally selected for this purpose, and 18 months later the Mint there was in operation. After the War, work on the new Calcutta Mint was resumed, but just when building operations were sufficiently advanced for the transfer of the machinery back from Lahore to Calcutta to be commenced, the partition of India took place, and the Lahore Mint, with all its new equipment, became the property of the Pakistan Government. It was then necessary to re-order the plant and equipment for the new Calcutta Mint, at post-war prices and post-war delivery periods.

Due to this delay, and to constant labour troubles, the new Mint was not officially declared open until March of this year, although in fact it had been undertaking small scale coinage operations for several months previously. Meanwhile, the serviceable plant and equipment of the old Calcutta Mint had been gradually transferred to the new Mint, and the old Mint is now closed for coinage, although some of the main buildings are likely to be retained for a few years yet, principally for the storage of bullion.

The present active organisation of the Indian Mints thus comprises (a) the new Calcutta Mint, with a maximum out-turn capacity during the normal 7-hour working day of $1\frac{1}{4}$ million coins; (b) the Bombay Mint, with a capacity of 1 million coins daily; and (c) the Hyderabad Mint, with a capacity of 300,000 coins daily. As a matter of interest, the normal daily capacity of the Royal Mint in London (which supplies the requirements of the Colonies and many

* Institution of Production Engineers Journal, March, 1951.

foreign countries also) is a little more than 500,000 coins daily. The combined productive capacity of the three Indian Mints is considerably greater than that of any other country in the world, although the Philadelphia Mint is slightly larger than any of the individual Indian Mints. At our peak rate of production during the last War, when working continuously day and night, the combined rate of output from the three Indian Mints reached the immense figure of ten million coins daily, and during 1944 the Calcutta and the Bombay Mints each produced over 1,000 million coins. In peacetime, of course, the demand for coins is at a much lower level, and the Mints are seldom occupied at more than half their rated capacities. In fact, when I first joined the Mints in 1932, the Bombay Mint was entirely closed for coinage, and the Calcutta Mint was producing a mere 100,000 coins daily. It is on occasions such as these that our subsidiary activities enable our key staff to continue to be usefully employed, even though coinage output may be at a very low level.

SUBSIDIARY ACTIVITIES

Medals, Badges and Tokens

In the Calcutta Mint the largest subsidiary activity is the production of medals. That Mint supplies the entire requirements of the Armed Services and of the Government of India, for medals and badges. Until 1947, all medals and title-badges awarded by the Viceroy in the New Year and King's Birthday Honours Lists were also manufactured in the Calcutta Mint. Some of these, such as the O.B.I. Star, were beautiful and costly pieces of jewellery, but with the advent of Independence, the Indian Government decided to abolish the award of all titles and British decorations, and the manufacture of such badges has thus been discontinued, although it has been replaced to some extent by the creation of new awards for gallantry for the fighting services.

Although the Calcutta Mint possesses very large capacity for the production of medals, the Bombay Mint also undertakes the manufacture of these, principally for the public, on a considerable scale. Both Mints manufacture the necessary dies for the purpose, if required, and these are retained in their safe custody for use as and when required. Apart from supplying gold, silver, and base metal medals to Universities, Schools, Regiments and other institutions, the Mints manufacture a wide variety of miscellaneous articles, from free railway passes for officials, to peons' badges and canteen tokens. This aspect of our activities is constantly increasing, and it provides an interesting diversion from the comparatively routine work of coinage production.

The Refining of Silver

The Bombay Mint possesses a large electrolytic Silver Refinery, which was erected after World War I in order to refine the enormous quantity of silver rupee coins which became surplus to requirements when normal peace-time conditions returned, and this Refinery has been in continuous operation ever since, though it is now nearing the end

of its useful life. It will shortly be replaced by another refinery at the new Calcutta Mint, which is being built to refine the later type of silver coins of lower fineness, which are themselves now being withdrawn from circulation and replaced by pure nickel coins. The Bombay Refinery was specifically constructed to deal with coins of the old fineness (i.e. containing 91.6% silver) and, cannot refine silver of below 80% fineness, whereas the Calcutta Refinery will be able to refine the later silver coins issued between 1940 and 1946, which contain 50% silver and 50% alloy. Most of the silver which will eventually be recovered from these coins is ear-marked for the repayment of silver obtained from the U.S.A. under Lease-Lend during the War.

You may be interested to have a brief account of the process employed in the Bombay Silver Refinery. The Refinery is equipped with 252 glazed stoneware cells, similar in shape and size to a large kitchen sink, and lined with graphite slabs on the base of each cell. These cells are filled with a strong solution of silver nitrate, and across the open top of each cell is laid a shallow wooden tray, lined with cloth. The base of each tray is slatted, and is immersed in the silver nitrate solution. The silver coins which are to be refined are placed in the trays—each of which can hold approximately 4,000 rupee coins—and these form the anodes for each cell. The liquid silver nitrate itself forms the electrolyte, and the graphite slabs at the base of the cells form the cathode. An electric current of low voltage and high amperage is passed through the cells, and this has the effect of gradually causing the silver coins to disintegrate into their component elements of pure silver, pure copper, and insoluble matter. The pure silver is precipitated in granular form (resembling crystalline sugar) on the floor of each cell, from which it is removed periodically by scraping, and is then washed, pressed into briquettes, dried, and finally melted in a furnace and cast into ingots, each weighing about 80 lbs.

The copper from the coins goes into solution in the silver nitrate, thus forming a mixture of copper nitrate and silver nitrate, which becomes increasingly rich in copper. When the copper content of the electrolyte has reached a predetermined figure, the liquor is pumped out of the cells and replaced by fresh silver nitrate. The liquor which has been removed is then treated in order to cause it to precipitate its silver content, leaving behind a solution of pure copper nitrate.

This copper nitrate is then used as the electrolyte in a separate set of cells, in which its copper content is deposited in metallic form on to thin strips of pure copper. These strips are removed when they become heavily coated with copper, and are melted and cast into ingots. The residual liquid in the copper cells is thus transformed into weak nitric acid, which is suitably strengthened by the addition of concentrated acid, and is then used again for the preparation of silver nitrate for the silver-cells.

Finally, the insoluble matter which formed part of the original silver coins, and which mainly consists of the dirt and impurities which have collected

on the surface of the coins whilst in circulation, is periodically scraped off the cloth lining of the wooden trays in the silver cells. The value of this unpleasant looking 'sludge', as it is called, is that it also contains the very small amount of gold that is always present in silver that has not previously been electrolytically refined. This only amounts to 2 or 3 parts in 10,000 but in a large refinery such as that in the Mint, the annual value of the gold recovered in this manner amounts to several lakhs of rupees, which more than covers the entire cost of operating the refinery.

The 'sludge' is treated in a blast furnace, which enables the metallic contents to be recovered, consisting of a mixture of silver, copper and gold. This alloy is then immersed in nitric acid, which dissolves the silver and copper, leaving the gold behind in metallic form.

The operation of the Silver Refinery is continuous, day and night. When working at full capacity it requires 2½ tons of silver coins daily to feed the silver cells, from which are obtained approximately 18 million ounces of fine silver each year.

The Melting and Refining of Gold

Bombay is the principal Bullion Market of India, and the Bombay Mint is thus conveniently situated to deal with the requirements of the banks and bullion merchants in this respect. The Mint possesses a medium sized Gold Refinery, which is operated by the chlorine process, and which is able to refine 8,000 tolas (200 lbs) of gold daily. The entire output of the Kolar Gold Fields is flown to us each fortnight for refining and casting into exact weight bars before sale. Large quantities of gold are also received from banks and from the public for melting and assay, without refining. All the gold which is detected whilst being smuggled into India is eventually sent to the Mint, and the ingenuity of the smuggler is amply evident from an examination of some of these receipts. At least £500,000 worth of gold passes through the Bombay Mint in these various ways each week.

The method of operation of the Gold Refinery is, as regards the main process, a very much simpler matter than that of the Silver Refinery. The gold to be refined is melted in crucibles inside oil-fired furnaces, in lots of 1,400 tolas (35 lbs) at a time. When the gold is molten, a hollow clay pipe is inserted into the liquid gold, and the upper end of this is connected by means of a flexible pipe to a cylinder containing chlorine gas. This gas is then allowed to bubble through the molten gold. Whilst doing so, it attacks all the impurities in the gold (which normally consist of silver and copper) and converts them into chlorides. These chlorides, being of lower specific gravity than the gold, rise to the surface of the molten metal, and form a gradually thickening crust above it. The completion of the refining process at once becomes evident when the chlorine gas, finding no more impurities to combine with, starts to bubble freely from the surface. The crust of chloride is then skimmed off the surface of the molten gold, and the gold itself is cast into ingots. The chloride is separately treated later in order to

recover its silver and copper contents in metallic form.

Although this method of refining is basically simple, it is one which requires long experience before satisfactory results are obtained. Chemically pure gold is never required, except for laboratory purposes and what is commercially known as 'fine gold' is that which contains not less than 99% gold. The assay fineness of precious metals is computed to two decimal places, and almost all our clients at the Mint require their gold to be of a particular fineness. A really good refiner will be able to work within a tolerance of ± 1 per mille. In other words, if he is asked to refine a consignment of raw gold to a fineness of approximately 99.3%, he will be able to ensure that no bar that is cast after refining will be of a fineness lower than 99.2% or higher than 99.4%.

The Dross Recovery Department

In this department any material which has been in contact with precious metal, and which may therefore contain particles of gold or silver, is treated in order to extract the metal from it. This material consists principally of slag and clinker from the blast furnaces; refractories which have been used as furnace linings; and charcoal which has been used as a de-oxidiser on the surface of molten gold or silver.

The material is first crushed in a pulveriser (or in an ordinary grinding mill if it is not too hard), and is then passed through a mechanical sieve. The coarser particles of dross which are rejected by the sieve are returned for further crushing, and the fine particles are then treated for the extraction of their precious metal contents. This is achieved by the use of a simple but ingenious machine, known as a James Sand Table, which operates by application of the fact that the density of the particles of precious metals which are contained in the powdered dross is very much greater than that of the dross itself. The machine consists of a flat rectangular table, inclined slightly off the horizontal both longitudinally and latitudinally, on the surface of which is fixed a number of shallow riffles which run diagonally across the table. The table is mechanically vibrated in the horizontal plane, and a stream of water from a perforated pipe flows continuously across it. The dross under treatment (which resembles coarse sand) is fed on to one end of the table by means of a chute. The stream of water across the table carries with it the light particles of dross which fall into a large sump which is installed below the table and along its entire length. The heavy particles of dross, which consist of gold or silver, are prevented from being swept off the table with the stream of water, by the diagonal riffles. They lodge up against these riffles, and due to the vibratory movement of the table combined with its downward tilt along its length, they move slowly along the riffles to the far end of the table, where they fall into a separate sump.

A remarkably high degree of concentration is obtained in this manner, and the gold or silver contents of this sump are then easily recovered in metallic form after being concentrated still further by a simple process of hand panning. A sample of the rejected

dross which has collected in the main sump is then sent for assay, and if it is found still to contain gold or silver beyond a certain minimum quantity, it is passed over the table again. When the precious metal contents of this dross is found to be below the prescribed minimum figure, the dross is removed and set aside for future sale. There are certain firms abroad which specialise in the recovery even of the very small precious metal contents of these 'exhausted' drosses, and it is remarkable that even after meeting all charges for bagging, freight and treatment, we still obtain about Rs. 30,000/- annually from the sale of these rejections, from which we ourselves have already extracted practically their entire metallic contents.

The Assay Department

Both the Bombay and Calcutta Mints possess large and fully equipped Assay Laboratories. These, whilst primarily intended to render technical assistance to the Mints with metallurgical problems, and to keep a constant check on the purity of the coinage that is issued from the Mints are also occupied with research work and with assaying samples of gold and silver received from the public for tests. The Assay Certificates which are issued from the Mints in respect of the fineness of each consignment of precious metals that has passed through their hands are recognised throughout the world, and enable the owner to sell his gold or silver bars at the current market rate without question, in accordance with the fineness shown on the accompanying Assay Certificate. This fineness is also stamped on each bar, together with the Mint mark.

The two Assay Departments in Bombay and Calcutta, together with the new Silver Refinery which is about to be constructed in Calcutta, have been grouped together as a separate Government Department since April 1st of this year, and are no longer an integral part of the Mints, although, of course, we will still continue to be closely associated with each other.

Weights and Measures

The Mints are each equipped with a Weights and Measures Department, in which standard weights and measures are manufactured and supplied to the various State Governments. We have in our possession the All-India Primary Standard Weights, manufactured in iridio-platinum, which themselves are derived from the British Primary Standard Weights. These are used only to check the correctness of the most accurate weights that we manufacture, which are known as Reference Standards. One set of Reference Standards is prepared and supplied to each State Government which has introduced a Weights and Measures Act, and these are themselves used only at intervals of one or two years to check the sets of Secondary Standard Weights, one of which is supplied to the Headquarters of each District or Division in the State.

The Secondary Standards, in turn, are used periodically to check the sets of Working Standard

Weights which are issued to the Inspectors, who devote their time to testing the accuracy of the ordinary commercial weights which are in universal use by the public. Thus there are four different standards of weights in India (apart from commercial weights), *viz.* Primary, Reference, Secondary and Working, which differ from each other only in the various accurate limits of tolerance to which they are finished. The more accurate series of these weights are never touched with the bare hand, due to the possibility of corrosion of the metal, but are handled with soft cloth or chamois leather. When the verification of Reference Standard Weights is undertaken by the Mint, the operation is carried out in a dust-proof air-conditioned room, built on vibration-free foundations, in order to obtain the most accurate results possible.

Standard Liquid Measures (or Measures of Capacity) are supplied by the Mints in a similar manner. The accuracy of these measures is determined by weighment. They are filled with water—any surplus water being removed by means of a striking glass—and the difference between their weight when empty and when full thus enables their accuracy to be determined, after the necessary corrections have been made for temperature and barometric pressure at the time of weighment. Thus all Standard Measures are themselves derived from Standard Weights. The Mints do not manufacture Linear Measures. All Standard Weights and Measures are manufactured in Admiralty Bronze, and are of distinctive shapes, so that each category can be easily distinguished from the others.

Counterfeit Coin Section

As you will readily appreciate, one of our biggest problems is to discourage unauthorised competition in our particular line of business. Due to the very low standards of literacy and intelligence which prevails in India, particularly in the villages, this country has always been an exceptionally easy field for the counterfeiter to ply his trade. In many areas, almost any piece of metal which has some resemblance to a coin, can be passed into circulation. The lower the face value of the coin, the less likelihood there is of it arousing suspicion, and thus in the past even the lowest denomination coins, such as the pice, have been counterfeited in considerable numbers, as, although the profit margin was smaller, the risk of detection was also correspondingly less. With the greatly increased cost of metals during recent years, the incentive to counterfeit the lower denomination coins has practically vanished, and our efforts to check this practice have therefore been concentrated mainly on the more valuable coins.

The great majority of counterfeit coins are prepared by casting molten metal into clay moulds, for which a genuine coin has been used as a pattern, instead of being struck between steel dies in accordance with normal minting practice. Most of you will have noticed that the rupee coins which were issued after 1940 have a narrow groove around the periphery, in the centre of the milled edge, and that

there is an embossed design at the bottom of this groove. This procedure was a very successful attempt to stop the manufacture of cast counterfeit coins, as those of you who have foundry experience will appreciate that a coin of this type cannot be used as a pattern without expert knowledge which is beyond the scope of the normal bazaar counterfeiter.

The selection of pure nickel as a metal to replace the silver coinage since 1946, was also made partly with the object of preventing counterfeiting. Due to its very high melting point, nickel can only be melted in electric furnaces, which no counterfeiter is likely to possess. It also has the great advantage of being the only coinage metal which is naturally magnetic, so that in the event of a counterfeiter deciding to use another alloy of similar appearance, the genuineness of the coin can at once be tested by applying a magnet to it. If the coin adheres to the magnet, it is genuine, if not, it is counterfeit. For this purpose, we imported about two hundred thousand small pocket magnets when the pure nickel coins were first introduced, and these have been distributed all over the country to banks, treasuries, railway booking-offices, cinema box-offices, and all similar places where coins are handled in large numbers. As a result of these innovations, the incidence of counterfeiting in India has shown a welcome decrease during recent years.

The Mints are the final authority as to whether a coin is genuine or false. Whenever the police apprehend a gang of counterfeiters, or persons who are suspected of uttering counterfeit coins, the exhibits are sent to one of the Mints, where they are examined and reported upon by one of our counterfeit coin experts. These men, as you will appreciate occupy positions of great responsibility and are trained for many years before they are allowed to undertake such work, as it is upon their expert evidence that the accused persons will either be acquitted or sentenced to a term of penal servitude.

Specimen Coins

The Mints have in their possession dies for every type of coin that they have minted during their existence. These range from the William IV gold double mohur, dated 1835 — one of the most beautiful coins that has ever been produced — to the present day series of coins. From these old dies we still strike 'proof' or 'specimen' coins for numismatists throughout the world. Such coins are expensive to manufacture, as they are individually struck from highly polished dies, and are finished to exact limits of size and weight. Not more than two coins are supplied to any one applicant, who must also show that he is a member of a recognised numismatic society.

In view of the general interest that has been aroused by the new series of coins of the Republic of India, it has recently been decided to make available to the public complete sets of these coins, mounted in cardboard faced with imitation leather, at a price of Rs. 5/- per set. These coins are very considerably superior to the current production coins, which can be obtained at their face value, in uncirculated condition, from any Currency Office, but they are not

finished to the same accurate limits of size and weight as are the more expensive 'specimen' coins. Only the new Indian Republic coins are available in these mounted sets: the older coins being supplied individually as 'specimen' coins to collectors only.

Precautions against Theft or Loss

It is inevitable that in an organisation like the Mint, where bullion and coins are handled and stored in very large quantities, special precautions have to be taken to guard against burglary or theft. These precautions have been elaborated during the past century, and are now of a very comprehensive nature. A brief summary of them follows:—

(1) To guard against any attempt at external robbery, each Mint is surrounded by an unclimbable fence, which is patrolled day and night by armed police guards. During working hours, visitors to the Mint administrative offices are freely admitted through the main gate, but they are not allowed to enter the operative departments unless accompanied by a Mint official, nor to leave the Mint with any parcel or package unless they have obtained a pass to authorise its removal. The Mints are, of course, amply provided with strong-rooms, in which are kept our stocks of bullion and coins. The more important of these strong-rooms are fitted with double locks, the keys of which are in the separate possession of two responsible Mint officers, neither of whom can open a door unless the other is also present. Thus even a senior Mint officer would be unable to raid one of the vaults unless he entered into partnership with another equally senior officer; and outside working hours, when the Mint is closed, this would also require the collaboration of a third party—the Warden of the Mint—in order that the main door of the Mint could be opened so as to gain access to the vaults.

(2) The main door of the Mint and the entrances to all Mint departments, are guarded by members of the Mint Police Force. These men are responsible for searching every workman whenever he leaves his department, and at the close of work a double search is made, once at the door of each department, and once at the main door. No workman is allowed to bring money in the form of coins inside the Mint, and pocketless clothing is compulsory.

(3) In every department where coinage metals in process of manufacture are being handled, the metal passing through the department is weighed in and weighed out. At the end of the day's work the residual quantities of metal, blanks or coins in the departments are compared with the opening balance, in order to ensure that the full amount has been correctly accounted for. This work is supervised by a staff of specially employed men known as Assistant Bullion-keepers, who work under the Deputy Bullion-keeper, and the Bullion-keeper himself. Each of these men has to pledge a Security Deposit to the Government on first appointment, the amount of which varies from Rs. 60,000/- in the case of the Bullion-keeper to Rs. 800/- for an Assistant Bullion-keeper.

The Mint Master is empowered to call upon the Bullion-keeper and his staff to make good any loss which may occur in those departments of the Mint,

or from the strong-rooms. The salaries paid to this section of the Mint staff may thus be compared to the premium on an insurance policy taken out by the Government of India to protect itself against any loss of coin or bullion from the Mint.

In spite of all these precautions, losses due to theft are by no means unknown and, if they are on a very small scale, they are difficult to detect, as it is impossible in practice for the daily departmental balances to be correct to the nearest coin, when several hundred thousand coins are being minted every day. The daily reports of departmental balances are therefore carefully watched, and so long as they maintain a steady average of plus or minus a few coins each day, there is no cause for anxiety. But if a steady succession of minuses starts to appear, or the minuses appreciably exceed the pluses over a period, then it becomes evident that something is wrong, and various additional precautions, such as a more thorough search of the men from the department concerned, are introduced. Fortunately, due to the weakness of human nature, a workman who once succumbs to temptation is rarely content to continue to steal only one or two coins at a time, which can be very difficult to detect, but he usually tries progressively to increase the size of his daily haul, and thus before long he is caught whilst being searched. Suitable rewards are granted to the Mint policemen when they detect a thief, and also to any workman who provides information which results in the apprehension of a thief.

Sir Alfred Herbert Paper Discussion

(Concluded from page 458)

(2) It is possible to apply radioactive materials for checking the thickness of spot or seam welded areas not accessible to normal means of measurement. This is one of the chief advantages of gamma-radiography, and considerable industrial use has been made of radioactive sources for examining welds in pipes and other relatively inaccessible components. Some examples of their use in examining pipe welds are given in Sir John Cockcroft's Paper.

(3a) It is possible to use radio-isotopes for checking the velocity of air flow along a pipe. To the best of our knowledge this has not yet been done, but it is already being considered. One method would be the injection of a small volume of radioactive gas into the air stream and its timing between successive points. Another method would be to measure the dilution of a trickle of high activity gases when the mixed gases arrive at the outflow.

A radioactive anemometer is already commercially available.

(3b) Measurement of gas leakage can sometimes be made by radioactive means, but other methods of gas detection are generally more practicable.

(3c) Distributions of air flow are very difficult to measure by radioactive means, mainly because the range of radiation in a gas is generally fairly high. Problems of this kind are already under consideration, but so far no successful technique has been evolved.

Conclusion

In this Paper I have only attempted briefly to describe some of the more interesting of the subsidiary activities of the Indian Mints, which are peculiar to the Mints, and therefore cannot be found in any other institution. There are other aspects of our organisation which are common to most other large factories, amongst which may be mentioned our general workshops, which employ some 250 men in each of the two larger Mints, and in which we are able to repair or replace the majority of our plant and equipment, and also to manufacture a large part of our day-to-day requirements of articles for use in the various Mint Departments.

Our welfare activities for the employees under the charge of a Labour Officer, include recreation centres, canteens, and flourishing Co-operative Credit Societies. Each Mint is equipped with a dispensary, for treatment of injuries and ailment of a nature which do not require admittance to hospital, and in the Bombay Mint the Ration Shop for the staff has over 15,000 customers on its books. The Supervisory Staff of the Bombay and Calcutta Mints possess their own recreational clubs, which in Bombay provide facilities within the Mint grounds for tennis, squash, swimming, billiards, dancing, and—in happier days—drinking. As I said at the start of this Paper, I have specifically excluded any reference to the actual processes of coinage production, and I think that you will agree that our other activities range over a surprisingly wide and varied field.

(4) The simplest way of illustrating the economics of gamma-ray autoradiography is by a series of data sheets (obtainable from the Isotopes Division, Harwell), from which the source strengths required for various types of irradiation can be calculated. The costs of the appropriate sources are also given.

(5) To the best of our knowledge, chemical reactions on a large scale have not yet been economically produced by the use of radioactive material. This question is under study, and further details may be obtained from Dr. R. Spence of the Isotopes Division. It has already been shown, however, that cross linking in polymers such as polystyrene can be induced by neutron irradiation.

FORTHCOMING INSTITUTION EVENTS, 1953

Institution Annual Dinner, Guildhall, London, 9th October.

Worcester Sub-Section Inauguration Meeting, 10th October.

Sheffield Section Dinner, 12th October.

Western Section Dinner, 15th October.

Coventry Section Dinner Dance, 30th October.

Lincoln Section 10th Anniversary Dinner Dance, 5th November.

George Bray Memorial Lecture, Leeds, 9th November.

Nottingham Section Dinner, 18th November.

Viscount Nuffield Paper, London, 16th December.

Aircraft Production Conference, Southampton, 19th/20th December.

NEW BUILDING FUND APPEAL

Since the publication of the last list, donations have been received from the following subscribers.
(This list was compiled for press on 14th September, 1953.)

Acton Bolt Ltd.
A. J. Aiers, M.I.Prod.E.
Airwork General Trading Company
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J. Ross Anderson, M.I.Prod.E.
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W. N. Axtell, Grad.I.Prod.E.

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G. Beaton & Son Ltd.
S. G. Bennet, Stud.I.Prod.E.
Blackburn & General Aircraft Ltd.
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E. Burgess, M.I.Prod.E.
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H. Busby, A.M.I.Prod.E.
R. F. H. Bush, A.M.I.Prod.E.
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W. Castledine, A.M.I.Prod.E.
C. C. Clogstoun, Grad.I.Prod.E.
Miss K. M. Cook, A.M.I.Prod.E.
J. A. Crabtree & Co. Ltd.
T. S. Crabtree, M.I.Prod.E.
R. H. Cubitt, A.M.I.Prod.E.
G. Cubitt-Smith, Grad.I.Prod.E.

K. Davies, Grad.I.Prod.E.

D. S. M. Eadie, A.M.I.Prod.E.
Edmonton Tool & Engineering Co. Ltd.
A. D. Edwards, A.M.I.Prod.E.
E. Percy Edwards, M.I.Prod.E.
A. J. Ellis, Grad.I.Prod.E.
C. Ellis, A.M.I.Prod.E.

The Fairey Aviation Co. Ltd.
Fescoll Ltd.
G. A. Firkins, A.M.I.Prod.E.
Firth Brown Tools Ltd.
J. T. Fitzgerald, M.I.Prod.E.
Ford Motor Company Ltd.
I. Fowler & Co. Ltd.
M. L. Freeman, Grad.I.Prod.E.

P. N. F. Gabb, Grad.I.Prod.E.
The Gear Grinding Co. Ltd.
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J. C. Goldie, A.M.I.Prod.E.
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R. W. Hall, Grad.I.Prod.E.
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M. Hustwait, A.I.Prod.E.
R. Hutton, Stud.I.Prod.E.

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The Ironside Engineering Co. Ltd.

P. Jack, Grad.I.Prod.E.
R. S. Jagger, Grad.I.Prod.E.
L. W. Johnson, M.I.Prod.E.
J. Parry Jones, Grad.I.Prod.E.
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A. G. McKinnon, Stud.I.Prod.E.
G. McPherson, A.M.I.Prod.E.
T. G. H. Middleton, A.M.I.Prod.E.
J. Millett, Stud.I.Prod.E.
F. H. Mills, M.I.Prod.E.
G. E. R. Mobley, Stud.I.Prod.E.
W. J. Morgan, M.B.E., M.I.Prod.E.
A. C. Moseley, Stud.I.Prod.E.
D. G. Murray, Grad.I.Prod.E.

H. R. Newman, M.I.Prod.E.
The Newall Engineering Co. Ltd.

C. L. Old, M.I.Prod.E.
W. A. Orr, A.M.I.Prod.E.
Samuel Osborn & Co. Limited.
The Owen Organisation.

N. Pardoe, Stud.I.Prod.E.
H. Park, Stud.I.Prod.E.
S. A. J. Parsons, M.I.Prod.E.
F. Partington, Grad.I.Prod.E.
A. W. Payne, A.M.I.Prod.E.
G. R. Pearce, Grad.I.Prod.E.
Percival Aircraft Ltd.
J. J. Poole, Stud.I.Prod.E.
E. M. Price, M.I.Prod.E.
G. E. Price, Stud.I.Prod.E.
Projectile Engineering Co. Ltd.

Ralphs Engineering Company Ltd.
Ratcliffe Tool Co. Ltd.
R. J. Read, Grad.I.Prod.E.
T. A. Rose, A.M.I.Prod.E.

R. T. Shackelton, Grad.I.Prod.E.
R. R. Simmons, A.M.I.Prod.E.
Lt. D. F. Skelton, Stud.I.Prod.E.
C. W. Skidmore, Grad.I.Prod.E.
T. G. Small, Stud.I.Prod.E.
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G. Egerton Smith, A.M.I.Prod.E.
R. N. Stallard, A.M.I.Prod.E.
W. H. Starr, B.E.M., A.M.I.Prod.E.
J. M. Steer, A.M.I.Prod.E.
W. F. Stewart, A.M.I.Prod.E.
J. Stone & Company (Holdings) Ltd.
J. A. Stubbs, Grad.I.Prod.E.

G. E. Toms, A.M.I.Prod.E.
A. E. Toon, Grad.I.Prod.E.
R. W. Travis, Grad.I.Prod.E.
E. J. Treasure, M.I.Prod.E.
S. Tyes, Stud.I.Prod.E.

R. H. Unwin, A.M.I.Prod.E.

A. Wainwright, A.M.I.Prod.E.
E. B. Walker, Stud.I.Prod.E.
R. A. G. Welscher, A.M.I.Prod.E.
O. Whitehead, Stud.I.Prod.E.
T. B. Wilcox, Grad.I.Prod.E.
K. G. H. Williams, Grad.I.Prod.E.
G. W. Wright, M.I.Prod.E.
S. B. Wright, M.I.Prod.E.

INSTITUTION NOTES

SOUTH AFRICAN SUB-COUNCIL AWARDS

The following Annual Awards are announced by the South African Sub-Council of the Institution:

For the Best Contribution to Production Engineering:

Mr. J. Steele, for his Paper entitled: "Modern Moulding Methods".

For the Best Contribution in its own Field: Mr.

H. J. G. Goyns, Member, for his Paper entitled: "Made in South Africa".

Student's Award: Mr. B. J. Bluhm, Graduate, who obtained the highest aggregate marks in three production engineering subjects in the Diploma Course of the National Examination.

The W. C. Gillespie Student's Award: Mr. N. J. Bohme, Student, who obtained the second highest aggregate marks in three production engineering subjects in the Diploma Course of the National Examination.

DEATH OF MR. A. J. MANSELL

It is with the deepest regret that we have to announce the death of Mr. A. J. Mansell on September 10th, 1953.

Jim Mansell was widely known throughout the Institution, and in his own sphere, his contribution to the progress of the Institution was outstanding. For eight years he served the Birmingham Section as Honorary Secretary and gave to successive Section Presidents, the committee and members, enthusiastic loyalty, effort and support.

He set an example in work and steadfastness which will be difficult to follow, and impossible to forget.

He will also be remembered for his work for the Hon. Secretaries' Conference, which, under his Chairmanship, has become an important part of the Institution's organisation.

Probably his most significant contribution to British Industry was the organisation of the Institute of Industrial Supervisors, of which body he was the first General Secretary. The growth of this body, and the place it has taken in Industrial life, is a tribute to his organising powers, brains and energy.

In addition, he was Honorary Secretary of the Birmingham Productivity Association, and was a member of the Institute of Industrial Administration.

Jim Mansell was taken ill whilst attending to his duties at the Summer School for the I.I.S., and passed away within a few hours. His life was dedicated to Public Service, and he will be missed in many spheres.

To Mrs. Mansell and her two daughters, we send our deepest sympathy in their grief.

SECTION HON. SECRETARIES—CHANGES IN OFFICE

The Institution records its appreciation of the work of two Section Hon. Secretaries who have recently resigned from office—Mr. W. J. Marshall, Member, of Wolverhampton, and Mr. R. S. Clark, Associate Member, of Manchester.

Mr. Marshall, who is General Manager of Bloor Industries, Ltd., Woore, has been Hon. Secretary of the Wolverhampton Section since 1947. His successor is Mr. W. B. Pamment, Associate Member.

Mr. Clark, who has carried out the duties of Hon. Secretary to the Manchester Section since 1949, is Manufacturing Engineer in charge of the Vacuum Products Department, Metropolitan-Vickers Electrical Co. Ltd., Manchester. He has been succeeded in office by Mr. R. G. Parker, Associate Member.

Both Mr. Marshall and Mr. Clark have devoted a great deal of time and effort to Institution activities in their respective Sections, and their work has been of considerable assistance in the continued progress of the Institution.

NEWS OF MEMBERS

The Directors of Wickman Ltd., Coventry, announce that Mr. H. Eckersley, Member, general manager of the Wimet Division, and Mr. W. V. Hodgson, Member, general manager of the Machine Tool Division, were recently appointed to the Board of the Company.

Mr. Eckersley, who joined the Company in 1935, was associated with the establishment of the new machine tool factory at Tile Hill, and was the first



Mr. W. V. Hodgson



Mr. H. Eckersley

works manager there. In 1940 he took charge of the branch office in Manchester until returning to Coventry in 1946, to take control of the Wimet Division and its tungsten carbide tool factories in Coventry and Glasgow.

Mr. Hodgson joined the Company in 1947 on relinquishing his directorships with the B.S.A. Tools Group of Companies. He is a past Member of Council of the Institution of Production Engineers and of the M.T.T.A., and has been general manager of the Machine Tool Division since 1949.

MR. D. D. LOWETH

Mr. D. D. Loweth, Member, is now a Director in the firm of Loweth & Partners (Industrial Consultants) Ltd., London.

MR. A. E. MORRIS

Mr. A. E. Morris, Associate Member, has recently been appointed to the Board of his Company, Gibbons Brothers Ltd., Dudley. Mr. Morris joined the Company thirty-four years ago as a boy in the machine and fitting shops, and has worked his way through the Works as marker off, foreman fitter, general machine shop foreman, head foreman and works manager.



Mr. A. E. Morris

MR. G. H. RIPPON

Mr. G. H. Rippon, Member, Managing Director of Maun Industries Ltd., Mansfield, has been appointed Chairman of the new Nottingham Local Productivity Committee. Mr. Rippon is Past President of the Nottingham Section of the Institution.

MR. J. D. TRIER

Mr. J. D. Trier, Member, will shortly be retiring from his post as Head of the Mechanical Engineering Department of the Technical College, Coventry, an appointment he has held for the past twenty-one years.

MR. FRANK G. WOOLLARD, M.B.E.

Mr. Frank G. Woollard, M.B.E., Member, has retired from the Boards of the Birmingham Aluminium Casting (1903) Co. Ltd., and the Midland Motor Cylinder Co. Ltd., with whom he has been associated as a Director for seventeen years. Mr. Woollard is continuing with his consulting and educational activities.

NEW APPOINTMENTS

Mr. J. G. Elting, Associate Member, has relinquished his post with C.A.V. Ltd., and has been appointed Section Leader in the Production Control Department of British Light Steel Pressings Ltd.

Mr. E. Fedder, Associate Member, is now General Manager of British Switchgear Corporation Ltd., Morden Factory Estate.

Mr. A. C. C. Gregg, Member, has resigned his appointment as Colliery Engineer with Wankie Colliery and has taken a post as Works Engineer with Rhodesian Alloys Ltd., Gwelo, S. Rhodesia.

Mr. D. F. M. Griffiths, Associate Member, has taken up an appointment as General Works Manager of Pegson Ltd., Coalville, Leics.

Mr. M. C. Hawkings, Associate Member, has relinquished his post with the General Electric Co. Ltd., Witton, and has been appointed a Technical Grade II Engineer (Mechanical Engineering Engines) in the Admiralty on production duties in Birmingham.

Mr. T. L. Isaacs, Associate Member, has taken up the position of Production Manager with "Engineering Productions", Clevedon, Somerset.

Major J. H. Partridge, R.E. (Retd.), Member, has been appointed Business Manager of the London Works of Wickman Ltd.

Mr. R. J. C. Whitaker, Associate Member, has been appointed Chief Production Engineer of The Glacier Metal Co. Ltd., Alperton, Middlesex.

Mr. D. O. Boden, Graduate, has been appointed Assistant Lecturer Grade "A" at the Chesterfield College of Technology.

Mr. N. D. Hodgekiss, Graduate, is now Sectional Aeronautical Engineer in the Department of Civil Aviation (D.A.N.), Melbourne, Australia.

Mr. D. Royston, Graduate, is now employed as a Production Engineer with the English Electric Co. Ltd., Luton.

Mr. A. F. W. Smith, Graduate, has now been invalided out of the Navy and is employed by Urwick, Orr & Partners Ltd., as a Work Study Engineer.

HAZLETON MEMORIAL LIBRARY

Members are asked to note that the Library will normally be open between 10 a.m. and 5.30 p.m. from Monday to Friday each week. During the month of October, full facilities will not be available at the following times:—

Thursday, 8th October all day.
Tuesday, 27th October from 2 p.m.

Wednesday, 14th October from 2 p.m.
Thursday, 29th October all day.

621.9091 TOOLS

"Design and Use of Cutting Tools", by Leo. J. St. Clair, New York, McGraw-Hill, 1952. 437 pages. Illustrated. Diagrams. \$7.00.

A large proportion of this book is devoted to a detailed analysis of cutting tool angles on single point tools. Several other chapters deal with other aspects of cutting tools and machining, such as tool materials and their correct selection, tool grinding and chip breakers. The influence of speeds and feeds on machining efficiency and tool life, and the basic considerations of chip formation are also dealt with in detail. The book is liberally illustrated by clear diagrams.

The detailed and thorough treatment of cutting tool angles is extremely valuable and almost unique among the large number of books on the subject of cutting tools. The detailed treatment is perhaps too involved and not altogether necessary for most Production Engineers, but certainly very useful to the serious student of the subject. The rather conversational style of the author, strangely enough, does not assist the reader to assimilate the information and frequent references to the author's experiences tend to break up the flow of explanations. The chapters dealing with subjects other than cutting tool angles are easier to follow, but on the other hand, do not contribute greatly to other already published matter. The book can be recommended to the specialist and to all with a serious interest in the subject. J.C.Z.M.

657.47 COST ACCOUNTING

"How to Control Production Costs" by Phil Carroll. McGraw-Hill, New York, 1953. 272 pages, diag. £2. 2s. 6d. (Industrial Organization and Management Series.)

This is a very readable book, but it rather depends on who is going to read it. The writer covers both the commercial and technical fields, and in doing so falls between two stools. To those who are already convinced that modern production cost control is an essential, the book serves to underline in a typical American way all that the expert already knows or should know.

To those who are convinced, but have not the necessary technical knowledge to apply modern systems, this book will be found an encouragement, not sufficiently detailed in terms of actual paper work examples.

To those who have yet to be convinced, the author will muddle rather than help, by being too technical on the one hand and too long in his general observations.

While the subject matter covered thus serves all three classes, it would have met a better purpose had it been written in three volumes, each addressed to the particular requirements of the three classes covered. To the pure technical expert, this book is a delight. To the Managing Director who is convinced that he needs to be convinced, and who is prepared to make allowances for the American outlook, the book should prove to be worth a small fortune. R.W.M.

658.5 PRODUCTION PLANNING AND CONTROL

"Production Control" by Paul D. O'Donnell. Prentice-Hall Inc., New York, 1952. 304 pages. £2.

The book covers the vast field of Production Control concisely and in a manner which should be easily understood by the British student without the aid of a glossary of terms, which usually is necessary with American technical works.

Twenty-two pages are devoted to an introduction, to prepare the student for the following twelve paragraphs, dealing with the various Production Control functions.

The author recognises that there is no standard Production Control procedure and his presentation of examples in companies of varying size and with varying products, is good. This emphasises the extent of the research and care that has been taken by the author and he has completed the difficult task of simplifying an essentially technical matter, in a manner that will appeal to the student.

Rather more is covered in the book than is required for an elementary knowledge of Production Control, but perhaps greater emphasis and more space could be devoted to the importance of "Design for Production". This stage of Production Control functions is of the utmost importance, since it affects most of the other routine procedures. The need to "narrow the gap" between the Design Engineer and the Production Engineer is probably evident in most manufacturing organisations, and the importance of cohesion between these two "Prime Movers" cannot be over-emphasised.

Whilst the author has dealt with his subjects in self-contained chapters, it would appear desirable to emphasise to the reader that all these functions should be considered as part of the flow line of the total manufacturing cycle. A full paragraph could be devoted to the full explanation of the manner in which the various functions are inter-related.

It is interesting to note that "Materials Handling" is covered by one of the most important chapters, and the author does well in giving a prominent place to what is usually a very poorly measured process in the manufacturing cycle. A good book, well presented, which should command a prominent position on the shelves of any technical library. C.E.A.G.

744: ENGINEERING DRAWING AND DESIGN

"Technique of Design" by P. J. Wallace. London, Pitman, 1952. 103 pages. Illustrated. Diagrams. 12s. 0d.

An interesting and useful book, written in a lighter vein than would be expected for this subject, and is a dedication to draughtsmen and designers.

The author has used, as a basis, the design of a Spinning Rig and around this are woven the problems which would confront the designer, and the procedures taken. Examples of these problems and some of the calculations are given, but the book is by no way of becoming a text-book. Several passages are in fact quite humorous, and the Drawing Office personnel

descriptions cover all the various personalities well known to draughtsmen and designers.

The book succeeds in illustrating that academic training alone does not make a designer; he must also acquire the technique of design. F.G.B.

669 METALS : METALLURGY

"Metallurgy for Engineers : Casting, Welding and Working", by J. Wulff, H. F. Taylor and A. J. Shaler. New York, Wiley; London, Chapman & Hall, 1952. 624 pages. Illustrated. Diagrams. £2. 14s. 0d.

This is definitely not a book for the experienced or practising metallurgist. The aim of the authors, all three of whom are on the staff of the Metallurgy Department of the Massachusetts Institute of Technology, was to meet the needs of general engineering students and their lecturers. In this, they have succeeded admirably.

The first part of the book is devoted to a clear exposition of the fundamental principles underlying the science of Metallurgy. The reader is led easily and smoothly to an understanding of the hitherto mysterious world of dendritic crystals, polycrystalline solids, equilibrium diagrams and eutectic systems. The just claims of austenite, pearlite and martensite to a place in the sun have not been ignored.

Chapter 9, the first concerning the Heat Treatment of Steel, is, perhaps, a trifle academical. The two immediately following, however, should prove of value to the embryo engineer.

Then follow a series of chapters dealing with the processes to which metals are subjected in the service of man. Casting, welding, brazing, forging, are only a few of the many processes with which the reader is made acquainted.

The text is eminently readable and generously illustrated. The chapters are just the right length for this subject, which needs to be split into doses, each of which can be easily assimilated if the learner is not to be frightened away. In too many books on metallurgy the author's interest in his subject comes first, the reader's needs, second. At the end of each chapter is a concise summary, a list of questions which helps both student and lecturer in revision and consolidation, and a short list of references.

To get the best out of the book an elementary knowledge of physics and chemistry is required. This should prove no obstacle to present day engineering students in this country, be they full-time or part-time students. An Appendix on the Selection of Metals and Processes is of some interest to Production Engineers. The authors have not forgotten to add an Index of 20 pages to a book which can be confidently recommended to the engineering student seeking a first acquaintance with metallurgy. D.E.G.

621.73 FORGING

"Forging and Forming Metals", by S. E. Rusinoff. Chicago, American Technical Society; London, Technical Press, 1952. 279 pages. Illustrated. Diagrams. £1. 12s. 0d.

The author has obviously given considerable thought to the method of presentation of the subject, but has tried to cover such a wide field that the book will be of little help to specialists.

Chapter 2, on metal quality, has brought out the main points in a simple and straightforward manner, but the remarks on choosing a suitable metal for a particular type of forging can be misleading to a student. The following Chapters (3/9) have covered clearly the various methods of forging, and explained the advantage of each method. However, the greatest advance in recent years has been in cold forming, and this subject is barely mentioned. The technical advantages of cold forming over hot forging are considerable, and should have warranted much more consideration than the scanty reference which has been made to this method.

Chapters 10/11/12 cover all the finishing operations, cleaning, heat treatment and inspection, but the information is scanty. Chapter 10 states that pickling for descaling steel forgings is carried out in sulphuric acid; this is true, but it is only one of many acid solutions used.

Chapter 11 has only briefly touched on the main methods of heat treatment and heat treatment processes, and it is doubtful if the type of reader who will peruse this book will understand what is meant by the critical point of steel. No explanation is given to the reader for the various heat treatment processes, normalising, annealing, spheroidising and hardening other than to heat to the critical range or above, and this is most misleading.

Chapter 12 only shows details of a very small number of the type of defects likely to be found in forgings. A considerable time has also been spent on giving spark characteristics of different irons, steels, and alloys, and this can be a very dangerous method of inspection, other than in the hands of a trained person.

The last four chapters are well presented and should give a lot of help to the engineer—design of dies and tools and product design especially.

The review questions at the end of each chapter have been well prepared, and any reader who can answer these questions satisfactorily will have a very good working knowledge of forging and forming. The reader, however, will require to refer to the bibliography for more detailed information on some of the processes, and I feel the author would have been well advised to give more space to actual forging and forming methods rather than cleaning, heat treatment, etc., after forming. T.C.P.

621.7913 SOLDERING : BRAZING

"Industrial Brazing", by H. R. Brooker and E. V. Beaton. London, Iliffe & Sons Ltd., for Welding and Metal Fabrication, 1953. 344 pages. Illustrated. Diagrams. £1. 15s. 0d.

This book is of considerable interest to the Production Engineer for two reasons; its authors have put over their combined intimate knowledge of all known phases of the art and practice of brazing as a means of fabricating metal and have at the same time paid careful attention to the setting out of contents in such orderly and readable form, that the questions and problems suggested to the mind of the critical reader are answered almost in the order in which they arise.

In the absence of such a comprehensive treatise upon brazing in all its branches, the engineer desirous of applying the technique has been obliged to gather together from many sources information concerning various methods, before he can select and properly apply the process best suited to the project he has in hand, often leaving much to trial and error before satisfactory results are obtained.

One is impressed with the authoritative character of the work in dealing with the principles and technicalities of the processes involved; it presents the possibilities of these in a manner enabling the engineer to judge readily their relative values.

The book contains 203 photographs and diagrams, and 32 tables. The clarity of expression is in the best tradition, and leaves no room for ambiguity, while the list of contents, bibliography and index, make it valuable as a work for reference.

Beginning with the history, definitions and scope of brazing in which the principles are discussed objectively, a chapter is devoted to various heating methods, with particular relation to the equipment, gases and atmospheres used in hand torch, gas burner, furnace, induction and resistance heating, salt bath and dip brazing. Emphasis is placed on the importance of joint design and the use of the phenomenon of capillary attraction. It is pointed out in Chapter Two that the aspect which is fairly stable is that of design and the variables are heating methods and brazing materials, an exhaustive treatise on which latter is to be found

in Chapter Three. Chapters Five to Ten discourse upon the application of the heating methods to different types of work in the order of the equipment described earlier. A complete chapter deals with the brazing of aluminium and another with special applications, e.g. the brazing of cemented carbides, stainless steel, etc. A final chapter on inspection completes the study in a manner which appeals to the Production Engineer concerned with the efficiency and economics of the process. C.R.W.

615.41 PHARMACEUTICAL PREPARATIONS : POWDERS, PILLS

"**Tablet Making**", by Arthur Little and K. A. Mitchell. *Liverpool, Northern Publishing Co., 1951. 123 pages. Illustrated. 15s.*

This book is confined to the making of medicinal tablets and deals with such items as general manufacturing principles; tablet making equipment, including details on their maintenance, and the compounding of some of the more common formulae.

The book is amply provided with illustrations of the various types of equipment in common use. G.C.T.

669.18 STEEL MANUFACTURE

"**The Story of the Mushets**" by Fred M. Osborn. *Nelson, London, 1952. 195 pages, illus. £1. 1s. 0d.*
David Mushet (1772-1847) and his son Robert Forester Mushet (1811-1891), were pioneers in the development of the iron and steel industry in Great Britain. The author made a life study of these men and their achievements and the book is the summary of his researches. A fascinating story of these two men and their associates is unfolded. In the case of David Mushet, he is described as an experimenter who made but little money. He discovered the Black Band iron ore in Scotland and it is claimed that he was the first to make ferromanganese. He also completed a great deal of useful experimental work on the technique of iron and steel manufacture. Robert Forester Mushet's achievements were rather more spectacular than those of his father and certainly more numerous. The father patented five inventions and the son patented fifty-four. The son is credited with two inventions of world-wide importance—firstly, the means by which the Bessemer process was made practicable for the large scale production of cheap steel, and secondly the first self-hardening tool steel.

There are several appendices, including a very pithy series of letters to the technical press urging R. F. Mushet's claims for recognition of his contribution to the Bessemer process.

From the biographical point of view, the book presents a stimulating story that all engineers could read with profit. From the technical point of view, the author has carefully collected a great deal of information of immense interest and the book may be regarded as a unique history in its own particular field. S.R.S.

725.4 INDUSTRIAL BUILDINGS

"**Management and the Building of a New Factory**" by C. W. Glover. *British Institute of Management, London, 1953. 36 pages, diags. 5s. (Production Management Series 6.)*

This small book is based on a paper given in the B.I.M. Winter Proceedings series 1952/53. The author describes the points that should be considered in deciding the type of factory and also considers in detail the factors that influence the selection of a suitable site.

The book then describes the types of buildings suitable for factories and details of their general construction. Lighting, heating, ventilating, drainage, and fire service, are dismissed very briefly, in common with a small section dealing with welfare facilities. This book suffers from one serious defect. It has been condensed into 36 pages, whilst the subject matter deserves ten

times that amount. For example, the section on re-organisation of factories has been condensed to 34 lines, and the subjects of canteen and welfare centre occupy only 15 lines. This is particularly regrettable since the book obviously represents the fruits of years of sound experience. S.R.S.

657 ACCOUNTANCY

"**MAPI Accounting Manual: Machinery and Allied Products Institute, Chicago.**" Prepared for the machinery and allied products, industrial equipment, and capital goods producing industries. *Chicago, the Institute, 1952. Charts. \$15.00.*

This is a completely revised version of a well-known volume. It has been prepared by a sub-committee of the Accounting Council of the Machinery and Allied Products Institute, all of whom are senior executives in American firms. It is not surprising, therefore, that the book gives a comprehensive picture of good contemporary applied accounting practice in the United States. The material is admirably presented in good English and clear layout and is entirely free from the padding so often found in American text books.

As its title implies, this volume is more a manual of good practice than a text book. It goes into considerable accounting detail but because the arrangement is so logical and the presentation so clear, it should be of interest and value to general managers and production executives as well as to accountants.

The outlook throughout the book is that of people accustomed to thinking of an accounting system as designed primarily to meet the needs of managers rather than auditors and shareholders' meetings. For this reason, the usefulness of the volume is not by any means entirely confined to American readers.

In line with best modern practice in this country, the whole approach is from the basis of logical classification and numbering of accounts and the clear presentation of information. Particular attention has been given to the accounting requirements of capital goods industries where production cycles are long, quantities small, pre-production expenses heavy, and erection and servicing charges customary. The book ends with chapters on profit planning and on the changing value of the dollar. There is a good index and a useful bibliography of American accounting literature. C.H.S.

535.6 COLOURS

"**Colour and Light at Work**" by Robert F. Wilson. *Sevenoaks Press Ltd., London, 1953. 148 pages, plates. £1. 5s. 0d.*

The author of this book is acknowledged to be an international authority on the subject of light and colour for industrial establishments. This is believed to be the first book to be published on the controversial matter of colour in factories and because the subject is controversial, the author is at pains to emphasise the interdependence of colour, lighting, architecture, cleanliness, worker psychology and the role of the expert colour consultant.

Colour terms and principles are dealt with first. These are followed by explanations of the need for studying the building layout and the worker psychology. Human prejudices about colour are studied and the opinions reached are supported by some statistical information, together with some interesting discussion of defective colour vision.

There is a lot of valuable information in this book provided that the reader can dig it out from the mass of anecdotes, opinions and propaganda in favour of expertly applied colour. The material is not arranged in a manner conducive to enabling the reader to grasp clearly how he should set about his own particular problems. It is felt that many of the points made by the author could have been emphasised by the judicious use of diagrams; twelve coloured plates in a book of 148 pages is sparse illustrating of a subject so largely concerned with vision.

The author emphasises that the present confusion which exists in relation to the understanding of colour in industry is due, in large part, to the information available which has been gleaned by physicists, psychologists and physiologists. It is only by a co-ordination of all three sources of information, coupled with experimentation, that the colour investigator can hope to do more than add to the existing confusion.

There is, however, hope of some order emerging from the present chaos. The author cites the case of the problems in decorating U.S. Army shore stations and the standardised range of a limited number of available colours, with which schemes to suit any geographical location can be worked out. Our own Ministry of Works have a limited colour range with which they design schemes to suit palaces or industrial buildings. The Production Engineer who reads this book can only hope that some standardisation of colour ranges and schemes be evolved eventually for his own guidance. C.T.B.

ABSTRACTS

539.16 RADIOACTIVITY

"Radio Isotope Techniques." Proceedings of the Isotopes Techniques Conference, Oxford, 1951, sponsored by the Atomic Energy Research Establishment. Vol. II. Industrial & Allied Research Applications. London, H.M.S.O., 1952. 177 pages. Illustrated. Diagrams. £1. 5s. 0d.

A summary of part of the Isotope Techniques Conference held in Oxford during July, 1951. The volume under consideration is devoted to the application of radio isotopes to Industrial and Allied Research.

Descriptions are given of metallurgical, chemical, and general applications; also Gamma Radiography, Counting Techniques, Non-destructive Testing, and Methods for the Elimination of Static Electricity.

Particular attention is drawn to papers dealing with the investigation of wear of metals by radioactive methods, also a method for assessing the wear of wire drawing dies. Papers are included on examination of castings and welds, together with comprehensive safety instructions.

This book has a preface by Sir John Cockcroft, the author of the Sir Alfred Herbert Paper, 1953, presented to the Institution of Production Engineers in July, 1953.

669.14 STEELS

"Symposium on High-Temperature Steels and Alloys for Gas Turbines." Iron and Steel Institute, London. London, the Institute, 1952. 395 pages. Illustrated. Diagrams. £3. 3s. 0d. (Special Report No. 43.)

This Report of a Symposium held in London in February, 1951 was published in July, 1952 as a single bound volume containing 37 Papers in 395 pages. Since the major stimulus for development of the gas turbine in this country was the pioneer work of Sir Frank Whittle on the aircraft jet engine, the Symposium was appropriately introduced by the fascinating story of those early days.

User and supplier aspects were covered by 15 Papers given by the leading designers and metallurgists concerned with the development of gas turbines and the materials used. These were further amplified in the discussion by distinguished visitors from Europe and the United States of America. Bowden pointed out that the cost and time of producing blades were prohibitive barriers to the economical production of large gas turbines, and that co-operation between the designer and the steelmaker was necessary to ease this position. Robertson, in considering future needs, discussed factors in making, shaping, and treating of materials and the production and properties of components. He pointed out that while casting or cold work might ease machining, this could not be permitted if the mechanical properties were impaired by such processes. Since aircraft gas turbine blades are difficult to forge, the dies used for precision forging have a very short life. Machining methods are, therefore, cheaper, in spite of substantial wastage of material. Rotors made

of disc forgings lend themselves to more thorough forging, heat treatment and inspection, but present a welding problem due to the nature of the materials used and the sections involved.

A group of three well-illustrated Papers covers welding and machinability aspects. Large discussed aspects of resistance, oxy-acetylene, carbon arc, argon arc and metallic arc welding of precision sheet work. The main factors in resistance welding are current value, time of current flow and mechanical pressure at the electrodes. These factors are different for high temperature alloys than for mild steel. Mention is also made of electrical spot riveting with stainless steel rivets, using a special type of hot welding machine. Bishop and Bailey discussed the weld metal properties and welding characteristics of two austenitic steels used for gas turbine rotors, using the metallic arc process. Wolfe and Spear dealt with the machining of austenitic and ferritic gas turbine steels. The machining technique for these alloys differs to a considerable extent from that used for conventional constructional steels. This Paper is concerned with the fundamental problems of tool material and design, cutting fluids, cutting speed, feed, depth of cut and the like.

In the other Papers the production of centrifugal and investment castings, scaling and fatigue, and special blade materials, including ceramics, were discussed. Although emphasis has been given in this review to component production, the major interest in the Papers is in metallurgical aspects.

621.3 ELECTRICAL ENGINEERING

"Higher Industrial Production with Electricity."

British Electrical Development Association, London. London, the Association, 1953. 146 pages. Illustrated. Diagrams. 9s. 0d. (Electricity and Productivity Series No. 1.)

This book has been issued by the Electrical Development Association to show how higher productivity can be obtained by the correct use of electricity. In particular, it is pointed out that this does not necessarily involve a great increase in the amount of electricity used but rather the more widespread and intelligent application of electrical methods, some of which use relatively little power. To this end, this book illustrates some of the most striking examples of what has been achieved in this line.

The advice to Production Engineers can be summed up under the headings of "Ideal Layouts", "Lighting", "The Use of Electric Motors", "Material Handling", "Furnaces and Heat Treatment", "Welding" and "Testing and Inspection". Each of these headings is further sub-divided into individual sections bearing on the main theme. Wherever possible, the various points are made in the form of case histories and these are suitably illustrated.

628.8 AIR CONDITIONING: REGULATION OF HUMIDITY

"Measurement of Humidity." National Physical Laboratory, Teddington, Middx. London, H.M.S.O., 1953. 18 pages. Illus. 1s. (Notes on Applied Science No. 4.)

The previous three books in this series give information on screw threads, aerodynamic techniques and electrical insulating materials. The book describes in simple language the physical principles of humidity measurement, and gives a description of several types of hygrometers, including wet and dry bulb, dew point, and mechanical and electrical types. Methods of checking the instruments are also given and the book is completed by notes on the accuracy and choice of method. There are five appendices including a list of books and references.

621.3 ELECTRICAL ENGINEERING

"Electrical Contractor's Annual, 1952-3," ed. by J. Rosslyn-Stuart, London, E. & F. N. Spon Ltd., 1952. 288 pages. 12s. 6d.

As its name implies, this book deals with electrical installation work more from the point of view of the

contractor than of the Production Engineer. There are, however, some useful notes on lighting and on the relative costs of water heating by electricity versus gas and solid fuel. Other sections cover estimating and costing, ring mains, television aerial installation, electric motors, electric refrigerators and other miscellaneous domestic appliances.

The book includes numerous tables covering all types of electrical data together with the trade names and addresses of most leading makers of electrical plant and equipment.

PAPERS RECEIVED

- 1968: "The Development of Steel and Tinplate Works—The Function of Lubricants and Process Oils" by W. Williams.
 1972: "Deep Drawing and Pressing of Stainless Steels" by A. C. Midgley.
 1973: "The Younger Outlook in Industry" by J. Wylde.
 1975: "Management Accounting and the Production Engineer" by H. H. Norcross.
 1976: "Factory Services" by R. E. Leahey.
 1977: "The Manufacture of a Large Waterwheel Generator" by R. H. S. Turner.

OTHER ADDITIONS

- 621.94 LATHES; SCREW MACHINES
 Cyrol, E. A. & Company, Chicago. "Standard Data for Turret Lathes and Hand Screw Machines." Lake Mills, Wis., Management Series Pub. Co., 1952. 113 pages. Illustrated. Diagrams.
 621.97 PRESS WORK
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 651 OFFICE ORGANIZATION AND METHOD
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 655.3 PRINTING
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 657 ACCOUNTANCY
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 658 INDUSTRIAL ORGANIZATION; MANAGEMENT
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 658.5 PRODUCTION PLANNING AND CONTROL
 Saunders, N. F. T. "Factory Organization and Management." 3rd ed. London, Pitman, 1952. 195 pages. Charts. 16/-.
 658.54 TIME AND MOTION STUDY
 Stansfield, R. G. "The Science of Work": German Work-study and Occupational Psychology: Conference at Hahnenklee . . . 1946. London,

Technical Information and Documents Unit, [194?] 97 pages. Typescript. 9/-. (B.I.O.S. Final Report No. 1799.)

658.562 INSPECTION; QUALITY CONTROL

- Butterbaugh, Grant I. "Bibliography of Statistical Quality Control": supplement. Seattle, Univ. of Washington Press, 1951. 141 pages. \$2.00.
 Dodge, Harold F., and Romig, Harry G. "Sampling Inspection Tables: Single and Double Sampling." New York, Wiley; London, Chapman & Hall, 1944. 106 pages. Charts. £1. 2. 0.
 Grant, Eugene L. "Statistical Quality Control". 2nd ed. New York, McGraw-Hill, 1952. 557 pages. Graphs. £2. 15. 6. (McGraw-Hill Industrial Organization and Management Series.)

658.7 BUYING; STORING

- Brohm, Henry D. "The What and Why of Stock Control." Urbana, University of Illinois, 1950. 28 pages. Illustrated. (University of Illinois—Business Management Service Bulletin 701.)

658.8 MARKETING

- Engineering Industries Association, London. "Export": A Handbook of Export Procedure. London, Engineering Industries Association, 1953. 40 pages.

660 INDUSTRIAL CHEMISTRY

- British Chemical Plant: (Directory of the British Chemical Plant Manufacturers Association. Biennial.) London, the Association, 1953. 356 pages.
 British Chemicals and their Manufacturers: the Directory of the Association of British Chemical Manufacturers (Inc.) London, the Association, 1953. 179 pages.

662.76 GAS

- British Gas Industry Productivity Team. "Gas: Report of a . . . Team . . . which visited the U.S.A. in 1952." London, British Productivity Council, 1953. 194 pages. Illustrated. Diagrams. 8/6d. (Productivity Team Report.)

669 METALS; METALLURGY

- United Nations—Scientific Conference on the Conservation and Utilization of Resources, Lake Success, 1949. Proceedings; Vol. II, "Mineral Resources." New York, U.N. Dept. of Economic Affairs, 1951. 303 pages. Illustrated. Diagrams. £1. 2. 6.

669.1 IRON AND STEEL

- Iron and Steel Directory and Handbook. 7th ed. London, Louis Cassier, Co. Ltd., 1953. 386 pages. £1. 5. 0.

669.2 NON-FERROUS METALS

- Organisation for European Economic Co-operation, Paris. "Non-ferrous Metals": Yearbook of Associations and Technical Publications of O.E.E.C. countries, Canada and the United States. Paris, O.E.E.C., 1952. 92 pages. 3/6d.
 British Non-Ferrous Metals Research Association, London. "Annual Report No. 33." London, the Association, 1953. 60 pages.
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- Wiggin, Henry, & Co. Ltd., Birmingham. "Notes on Machining the Nimonic Series of Alloys." Rev. reprint. Birmingham, the Co., 1953. 29 pages. Illustrated. Diagrams.

677.72 METAL CABLES; WIRE ROPES

- Walker, E. R. Forestier. "History of the Wire Rope Industry of Great Britain." Sheffield, the Federation of Wire Rope Manufacturers of Great Britain, 1952. 153 pages. Illustrated. Diagrams.

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THREE IN ONE

FINISH • DUCTILITY • DETAIL

ACHIEVEMENT



This ash tray is a perfect example of the combined properties of MAZAK. The fine plated finish is made possible through the basic smoothness of the casting—The excellence of detail demonstrates the high fluidity of the metal and the spun base shows that ductility is another noteworthy property.

Based on zinc purity of 99.99+%, MAZAK is the ideal die casting metal for ash trays and hundreds more articles.

MAZAK



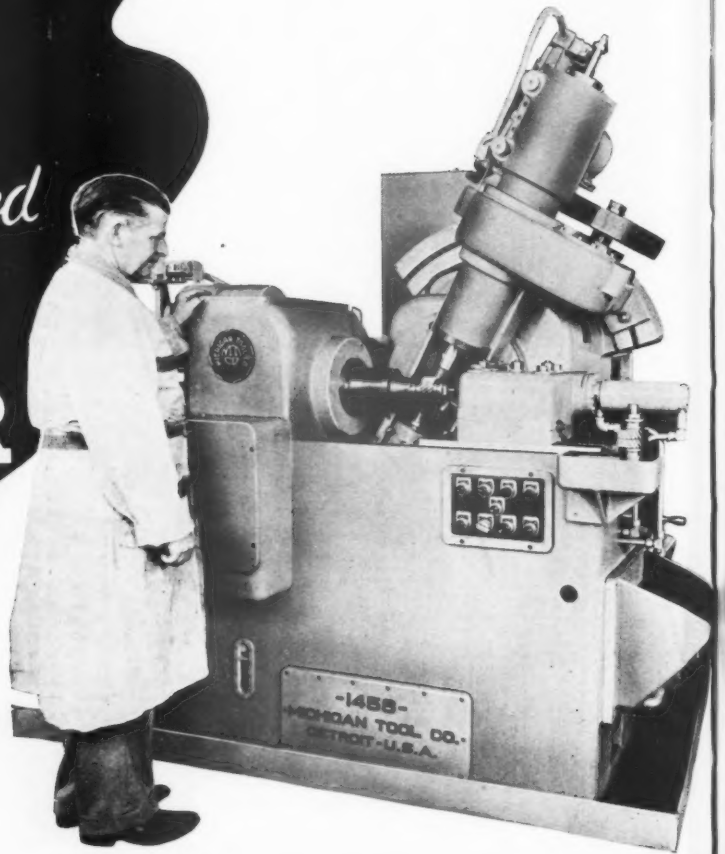
Now supplied in
ensure safety and



1 ton pallets to
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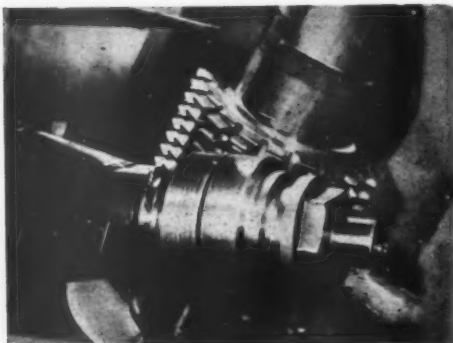
Announcing the new

MICHIGAN High Production High Speed GEAR HOBBER



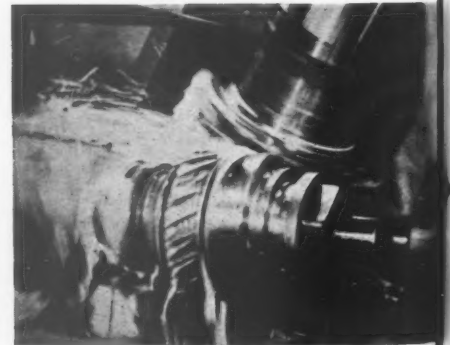
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Announcement Bulletin
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READY TO HOB TWO $3\frac{1}{8}$ " GEARS



Just before button is pushed
to start the cycle.

15 SECONDS LATER



Hob has completed its plunge cut and
transverse feed of work starts.

Rounding out its complete line of gear production machines and tools, Michigan Tool is proud to announce successful completion of development and production testing of its spectacular new high-speed high-production, single-spindle gear hobber — designed to make tomorrow's gear hobber requirements available today.

It employs a number of new design and operating principles developed and proven over a period of several years, all of which combine to give the Michigan Gear Hobber out-put rates which closely approach those of Michigan Underpass gear finishers and "Shear-Speed" gear sharpeners.

For example the Michigan Gear Hobber can finish-cut two $3\frac{1}{8}$ " diam. 9 pitch, (2 inch total face width) gears simultaneously to well within pre-shave tolerances, in a matter of 58 seconds, using high-speed steel hobs.

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SALES & SERVICE ENGINEERS FOR



Enables use of H.S.S. hobs at practically 'carbide' speeds.

Hob speeds up to 1000 r.p.m. or more available, if ever needed. (i.e. 1300 S.F.P.M. or more with a 5" hob).

Infinitely variable feeds at touch of a dial.

Gear accuracy virtually independent of machine operation.

Positive hydraulic dual feeds eliminate 2/3 of gears otherwise required.

Plunge feed replaces conventional approach feed; gives shorter total hob travel.

Torsional deflection and vibration eliminated, to all practical purposes.

Designed for push-button pre-selective hob shifting and automatic loading (optional equipment).

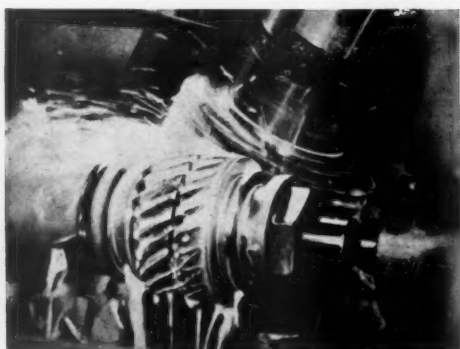
Quick positive setup, almost foolproof operation; high versatility.

One operator can easily run two or more machines despite high output rate.

Conforms to all J.I.C. standards.

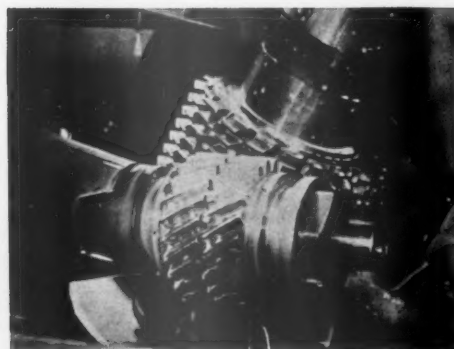
Rigid and compact.

... AT 37 SECONDS



Nearing the end of the climb cut.

FINISHED! IN 58 SECONDS



Ready for reloading.

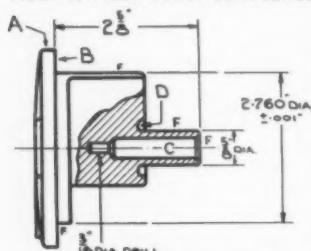
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Ward No 2A CAPSTAN LATHE

FITTED WITH 6½" 'PRATT' AIR-OPERATED
3-JAW CHUCK

PUMP BODY

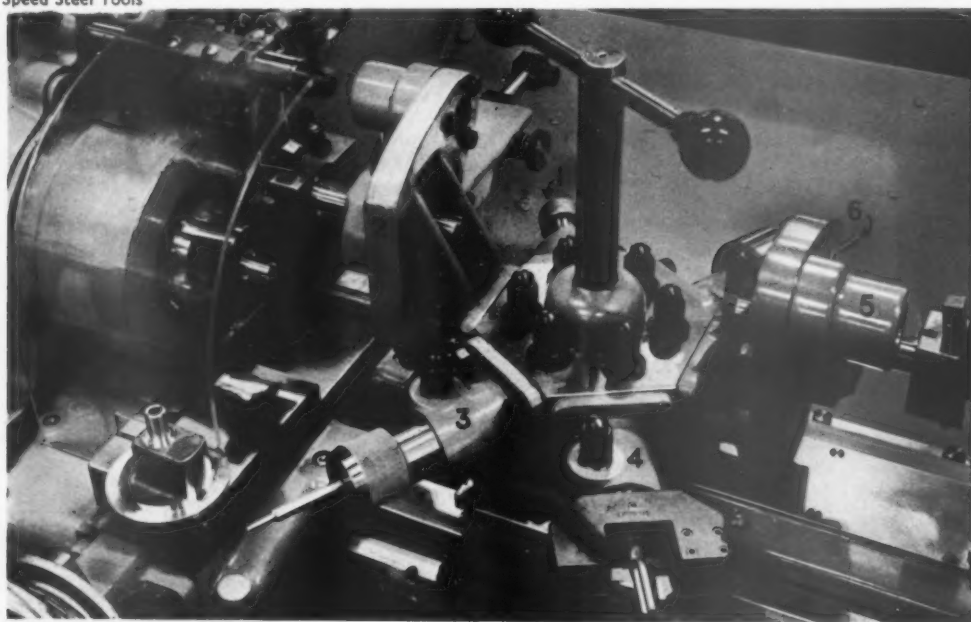
Floor to Floor Time: 50 seconds.



BRASS STAMPING

Tungsten Carbide and High
Speed Steel Tools

| DESCRIPTION OF OPERATION | Tool Position | | Spindle Speed R.P.M. | Surface Speed Ft. per Min. | Feed Cuts per inch |
|--|---------------|-------------|----------------------------|----------------------------------|--------------------------|
| | Hex.Turret | Cross-slide | | | |
| Chuck externally at A - - - | — | — | — | — | — |
| Face Flange B - - - | — | Rear | 2041 | 2000 | Hand |
| Start Drill C - - - | 1 | — | 2041 | 200 | Hand |
| Drill and Knee Turn 2.760" dia. - - | 2 | — | 2041 | 1475 | 120 |
| Drill 1/8" dia. - - - | 3 | — | 2041 | 100 | Hand |
| Bore C, Turn 5/8" dia. and recess D. and Face End - - - | 4 | — | 2041 | 535 | 120 |
| Finish Knee Turn 2.760" dia. - - | 5 | — | 2041 | 1475 | 120 |
| Ream C - - - | 6 | — | 321 | 30 | Hand |
| Remove - - - | — | — | — | — | — |



Capacity: 1½ in. dia. hole through spindle. 11¼ in. dia. swing over bed.

Spindle: Mounted in ball and roller bearings.

Powerful friction clutches running in oil transmit power through ground gears.

OUR COMPLETE RANGE INCLUDES CAPSTAN AND
TURRET LATHES WITH CAPACITIES UP TO 35 in. SWING
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Churchill

Churchill machines have set the standard for Universal Grinders due to their simplicity, combined with versatility and general efficiency on a wide range of work. Built in various swing and length capacities, the machines are readily adaptable for external and internal grinding and have full adjustments for taper and face grinding work.

THE CHURCHILL MACHINE TOOL CO., LTD., BROADHEATH, Nr. MANCHESTER

Export Sales Organisation: Associated British Machine Tool Makers, Ltd. London, Branches and Agents

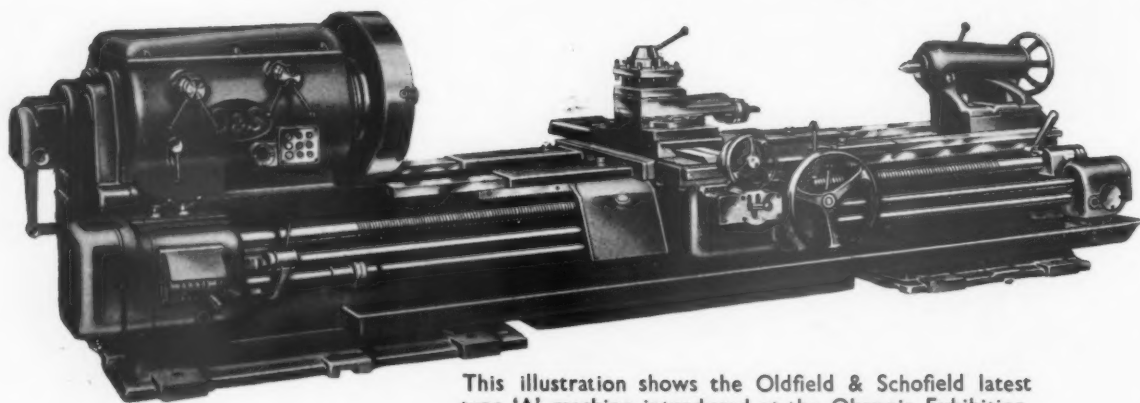
Home Selling Agents: Charles Churchill & Co., Ltd., Birmingham and Branches



PRECISION *plus* PRODUCTION

O & S LATHES

For the heavy jobs



This illustration shows the Oldfield & Schofield latest type 'A' machine introduced at the Olympia Exhibition. It has since proved to be outstanding where a robust machine is required. The wide range feed box and the single joy stick control on the saddle for saddle movements are very highly valued features. Machines have been installed in many plants.

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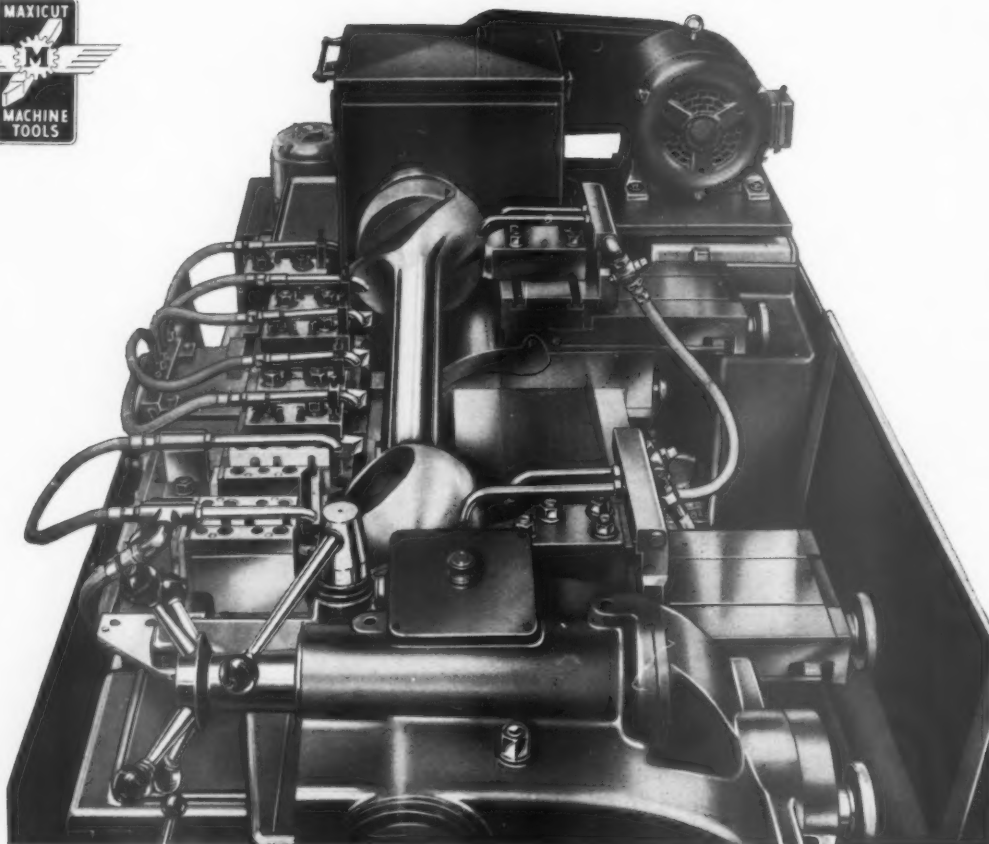
THE HIGH STANDARD OF ASQUITH "SPECIALIST" WORKMANSHIP STARTS IN OUR OWN MODERN FOUNDRY AT HALIFAX & IS CARRIED RIGHT THROUGH TO THE FINISHED PRODUCT THUS ENSURING A STANDARD OF HOLEMAKING SECOND TO NONE.

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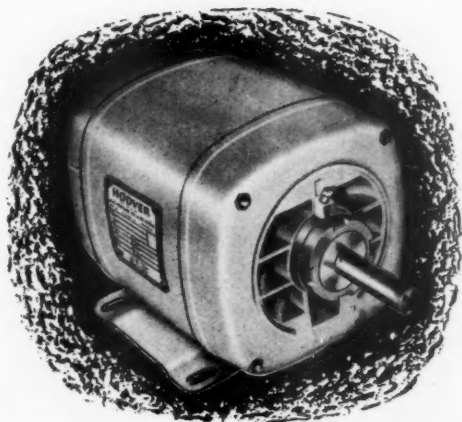
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WELLINGTON. The name itself is enough to convey an instant impression of one of the few men who have proved outstanding in Britain's history as both Soldier and Statesman—the incomparable Iron Duke. Such immediate recognition is a characteristic of *all* outstanding names. For example, to the industrial world the name Hoover represents the world's finest fractional horse power motor, unrivalled for its sturdy construction and trouble-free performance. Here is a 'fractional' successfully proved by manufacturers all over the world; backed by the renowned Hoover service plan.



The Hoover F.H.P. motor combines superb quality with competitive price. Please write for name and address of your nearest distributor.

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Rover Car Factory, Solihull. High intensity lighting in a body spray tunnel by fluorescent lamps in a glazed enclosure.

Tailored for the job

The lighting of many processes is vital to the smooth and rapid flow of work and to the quality of the finished product. For example, poor lighting could make a spray tunnel into a bottle-neck — each job taking a little too long, a little portion missed, a return to the spray line — and so the whole production line marks time. Whatever form it takes, good lighting not only helps to provide a satisfactory working environment but is an active production tool.

Fluorescent lighting is as good as daylight — only more consistent. It is efficient; it is economical; and it is *flexible*. You can 'tailor' it, easily and exactly, to the special requirements of production at all stages.

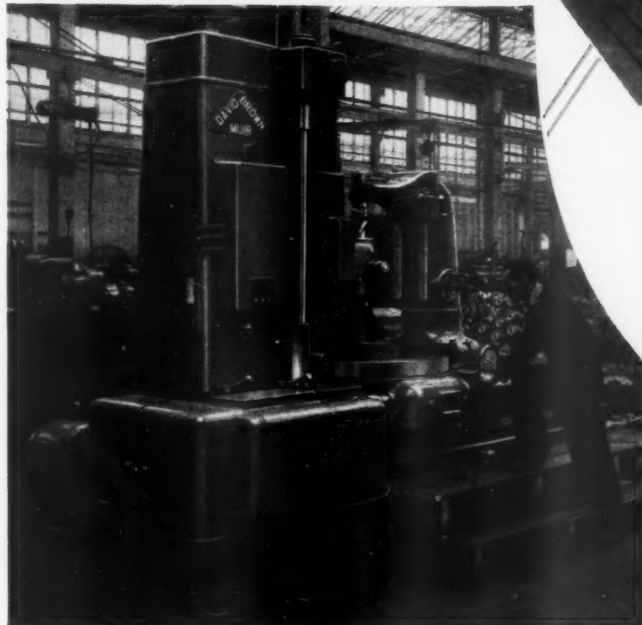
Electricity for **PRODUCTIVITY**

HOW TO GET MORE INFORMATION

Your Electricity Board will be glad to advise you on how to use electricity to greater advantage — to save time, money, and materials. The new Electricity and Productivity series of books includes one on lighting — "Lighting in Industry". Copies can be obtained, price 9/- post free, from E.D.A., 2 Savoy Hill, London, W.C.2, or from your Area Electricity Board.

Issued by the British Electrical Development Association

GEAR PRODUCTION



In the world's largest machine shops David Brown-Muir Hobbing Machines are now to be found in the high speed production of precision spur and helical gears, splines and serrations.

A range of machines extending to hobbing and shaving machines up to 200 in. gear diameter can be supplied.

We welcome your enquiries regarding specific problems and general descriptive literature is available at your request.

Above: M.T.30 Gear Hobbing Machine.

Below: M.T.60 Gear Hobbing Machine.

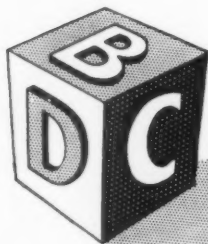
Both installed in the workshops of Vickers-Armstrong Ltd, Newcastle-on-Tyne.

THE
DAVID BROWN
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the whole in one



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That would stop their little games eh?

Running around the country selling things all over the place! Making nothing but work for everybody.

Silly?

Well, it's no sillier than the conditions permitted to hamper production in some factories.

In thousands of works production is slowed down because *seeing* conditions—nothing to do with lighting—*seeing* conditions, at the bench or machine are bad, and *nothing is done about it*.

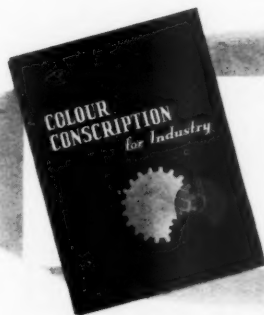
Bad *seeing* means tired eyes, fatigue, less output, absenteeism.

And a coat of paint could probably put it right!

"Colour Conscription for Industry" tells in a commonsense practical way, how colour can be conscripted to work for the benefit of employer and employed, and its effect upon production, upon absenteeism, upon the general attitude of the worker to his job.

The results of simply helping workers to see what they are doing are truly remarkable.

May we send you a copy of "Colour Conscription"?



PRODUCTION **UP** 10%
ABSENTEEISM **DOWN** 50% .

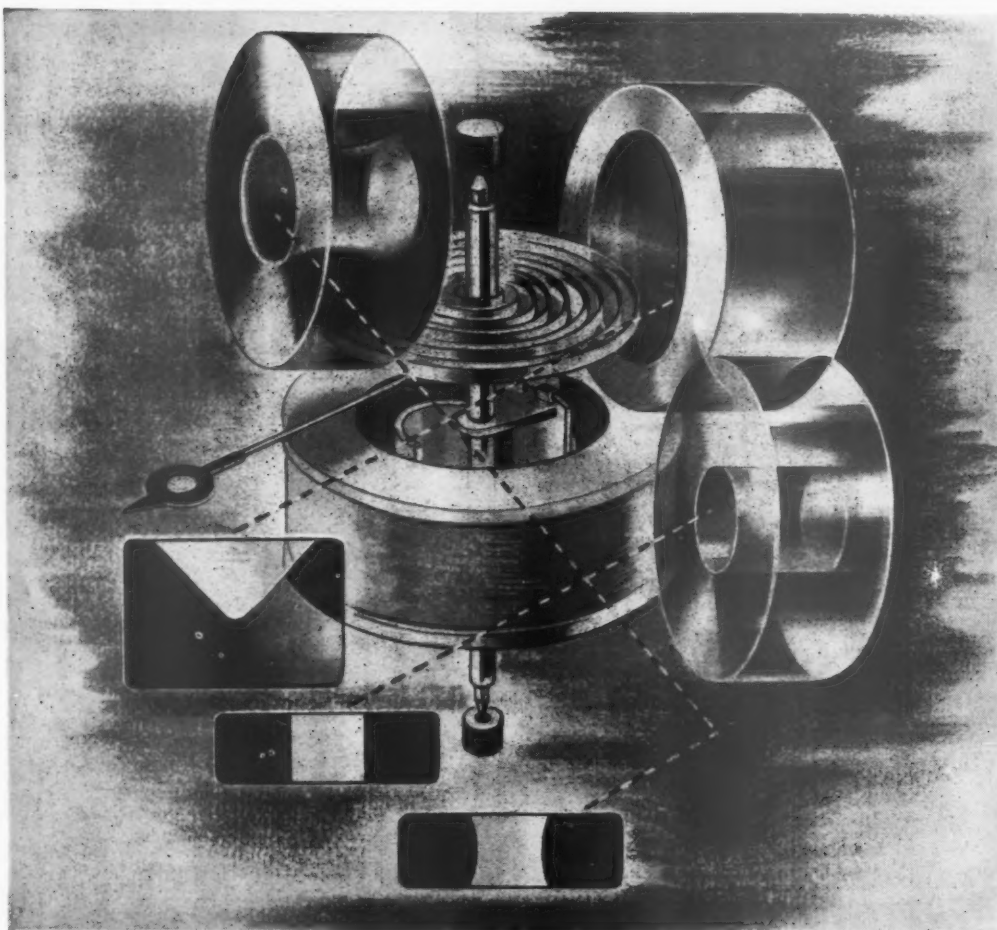
Such is the record of a well-known foundry after applying the principles described in "Colour Conscription."

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One forty-thousandth part of an inch is the unit with which fine diamond powder is measured. With such powder sapphire and ruby are ground to produce jewel bearings for watch, chronometer and scientific instrument. Accuracy is the key note. Only diamond powders graded to close, consistent and fine limits are of use.

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17 INCH SWING TOOLROOM LATHE

Dean Smith & Grace
KEIGHLEY LIMITED ENGLAND

DESCRIPTIVE CATALOGUES WILL BE SENT ON REQUEST



KEIGHLEY
MODEL

KN

precision internal grinder

This graph shows the roundness of bore of a component ground on a Keighley KN internal grinding machine which was installed early in 1944. The inner circle represents inaccuracies at 1,000 x magnification and the outer circle inaccuracies at 4,000 x magnification. The workhead has not been serviced since the machine was installed and the spindle and bearings are as originally fitted, and no adjustment has been found necessary.

The K.N. Internal and Face grinding machine. Capacity $\frac{1}{2}$ " to $5\frac{1}{2}$ "; bores up to 6" long.

**Bore Face and External
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SAME SETTING!**

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SHEETS OF METAL, bolts of cloth, packing cases — whatever you handle you'll find handling faster, smoother and cheaper when you put KING mechanical handling equipment to work. In one-man workshops and in mammoth factories KING pulley blocks, cranes and conveyors make heavy lifting and shifting a push-button job — and save, save, save all along the line.

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Whether you handle tractors or tennis rackets, cars or carboys, KING can show you how to help one man do the work of two with modern handling equipment. You may find a single electric pulley block is all you need — or you may decide to mechanise your handling completely. In any case it will pay you to consult KING.

You will find in KING booklets many useful

ideas about Overhead Conveyors, Floor Conveyors, Travelling Cranes, Electric Pulley Blocks and Runways. Write for these illustrated booklets and work out your ideas for cutting costs and speeding output.



**CONVEYORS
CRANES
PULLEY BLOCKS**

COVERED BY BRITISH PATENTS

Our Representative will call on you—anywhere in the world



Tins of paint and preservative flow from stores to dispatch on a KING Power Pulled Chain Conveyor at the Robbialac Works.



KING Cranes are doing a great job in factories all over the world. They are made to give long trouble-free service—and they do.

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clean as a

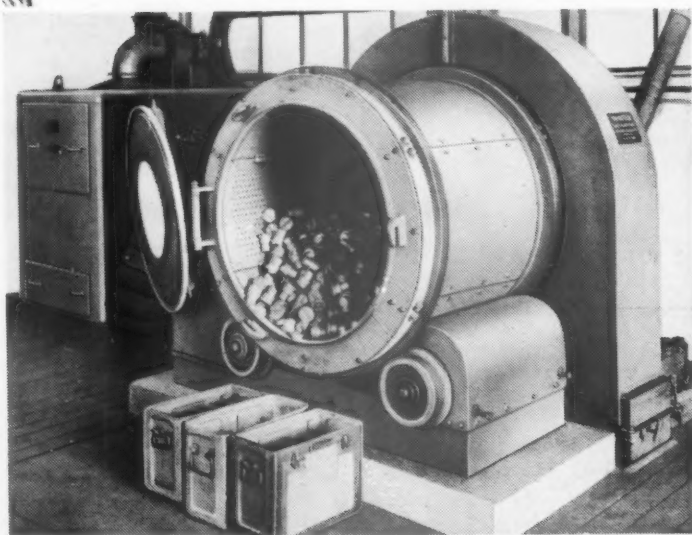
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Castings are cleaned in the "Centriblast" Airless Rotary Barrel Blast Cleaning Machine with speed, efficiency and economy. For large and small Foundries, Engineering Works, and Forges, the "Centriblast" provides the answer to the problem of producing "clean as a whistle" castings at competitive costs.

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GEAR TOOTH PRODUCTION

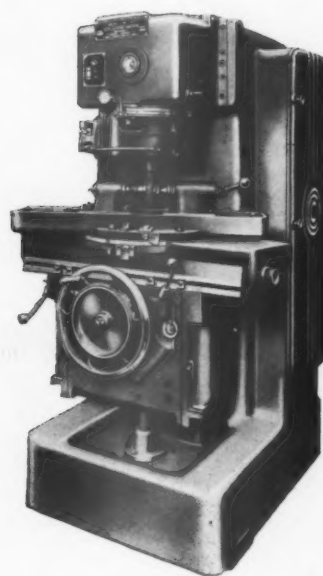
Shaving



This automobile main shaft gear has 27 teeth, 9.25 N.D.P., Helix angle $26^{\circ}-13'-15''$. Right hand, $\frac{3}{4}$ " gear face width. The material was EN 35A tensile strength 40 tons per sq. in. Finishing time was 40 seconds per component, finish-shaving teeth by diagonal methods to perfect elliptoid contour.

- Gear teeth crowns shaved .0005" per flank.
- Stock removed .008" over two pins.
- Two passes per machine cycle.
- Cup type arbors and automatic, air operated machine coolant guard were used.

**8in. CHURCHILL RED
RING DIAGONAL GEAR
SHAVING MODEL GCV.**



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CHURCHILL
& CO. LTD.

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speed the job !



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Over twenty years ago Mr. Neven introduced his Impregnated Diamond Tools. Great technical advances have been made in succeeding years and production is still under the personal supervision of Mr. Neven. Our latest catalogue gives the widest range of Diamond Tools yet listed for working tungsten carbide, glass, quartz, stone, ceramics and hard refractories, etc.

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ENSURES THE HIGHEST PRECISION AND PRODUCTION AT ROTOL LTD.

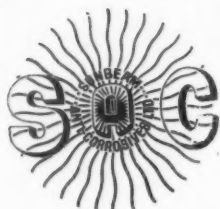
In this well-known factory PRECIMAX grinders handle a wide range of high precision aircraft work rapidly and efficiently, meeting all demands for close tolerances and the highest possible standard of finish. Our illustrations show a Model MPJ 2.72 machine engaged on a typical job on which seven diameters are finished to limits within 0.0005in.

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There are various grades of each of the above products available to meet all technical requirements and comply with Government specifications.

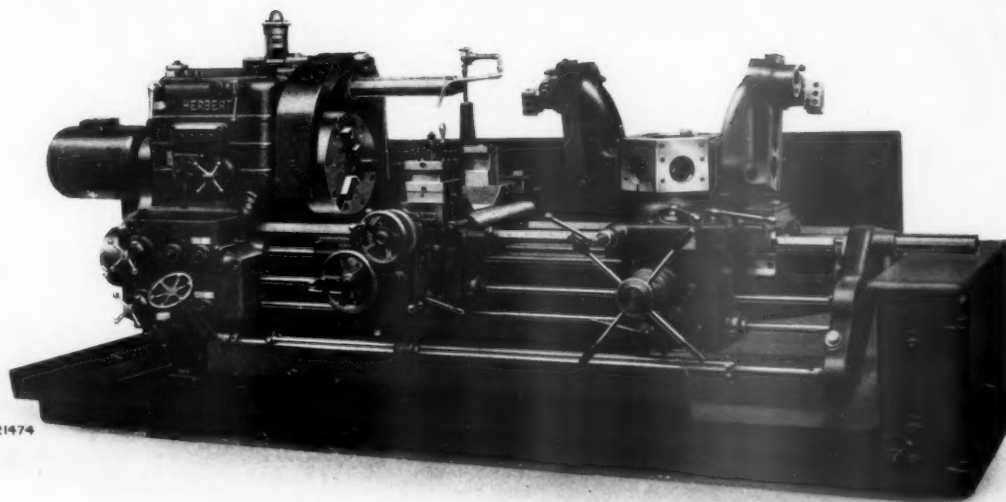
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BALL AND ROLLER-BEARING SPINDLE. HARDENED BED. PREOPTIVE HEAD gives any one of 16 speeds, forward or reverse, instantly, without stopping the spindle.

TWELVE INDEPENDENT FEEDS TO SADDLE AND TURRET.

QUICK-POWER MOTION TO TURRET IN EITHER DIRECTION.

CHASING MOTION cuts three pitches, right or left hand, with each leader.

SQUARE TURRET ON CROSS SLIDE is of our quick-acting type.

TAPER ATTACHMENT can be supplied if ordered with the machine.

HAND, AIR OR ELECTRICALLY-OPERATED CHUCK CAN BE FITTED.

ELECTRICAL EQUIPMENT IS FOR 200/250 volts, 3-phase, 50 or 60 cycles.

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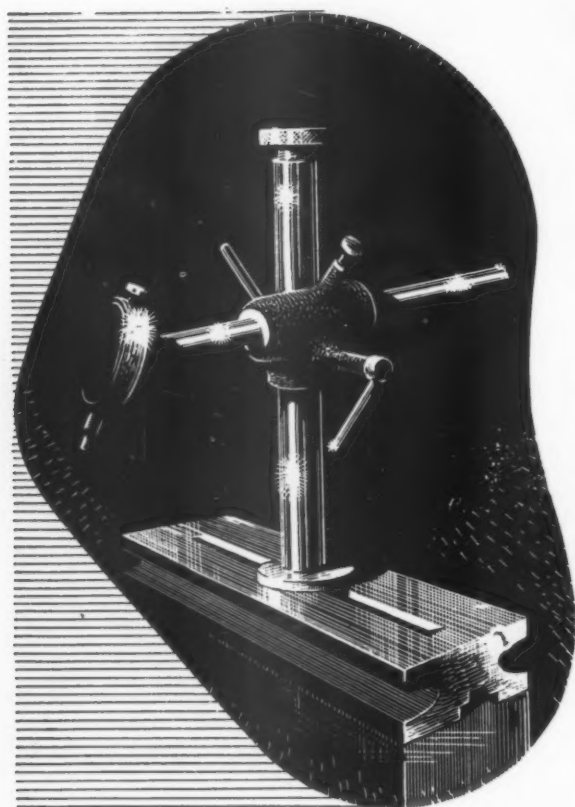
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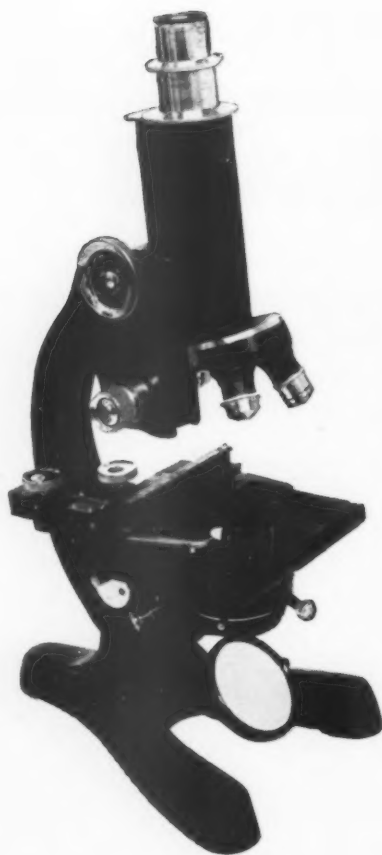
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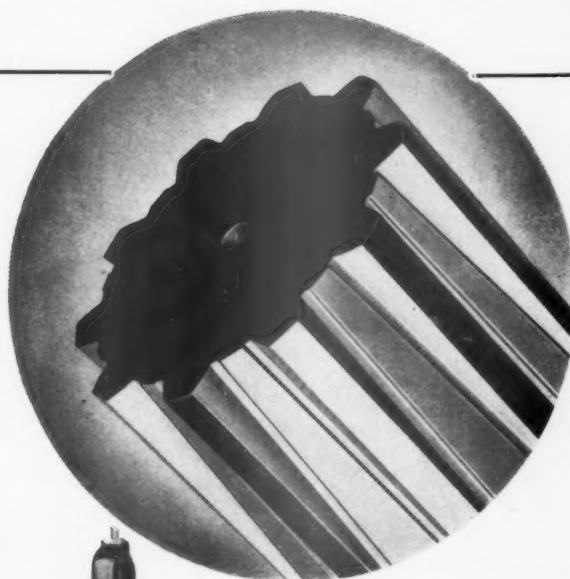
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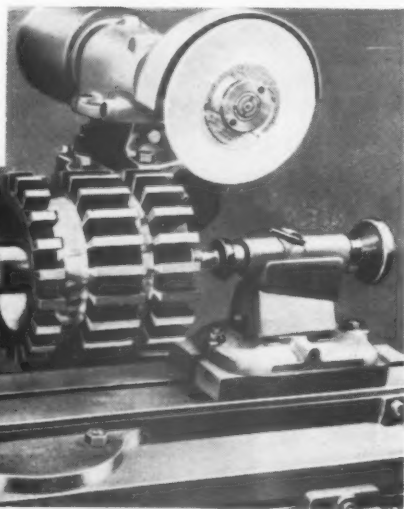
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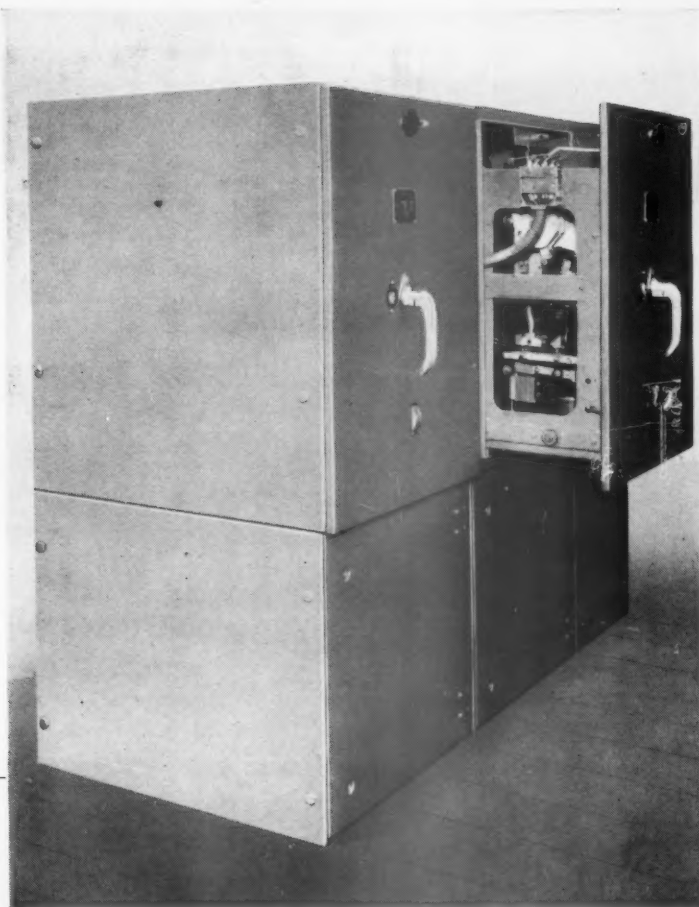
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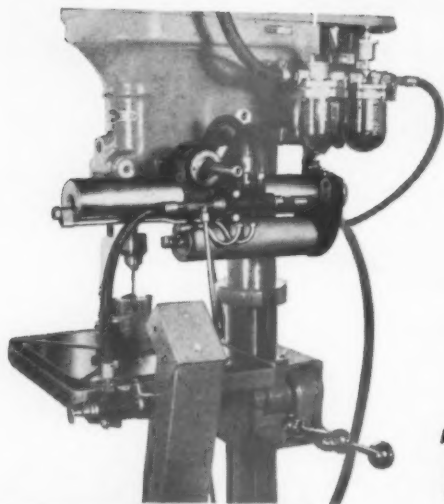
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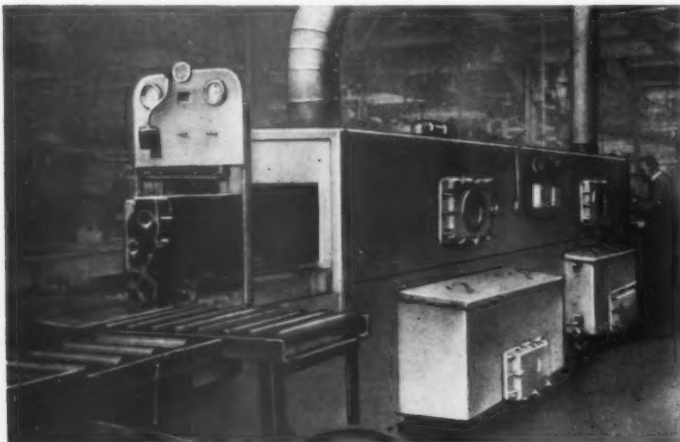
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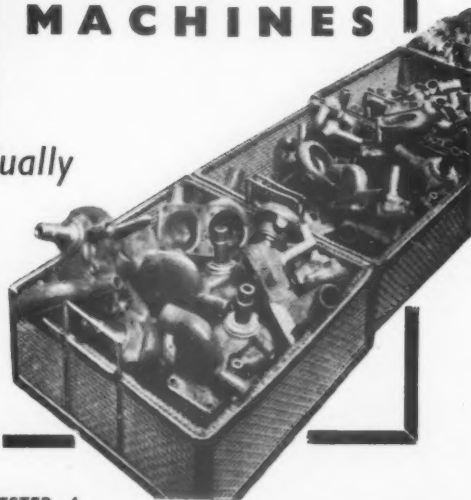
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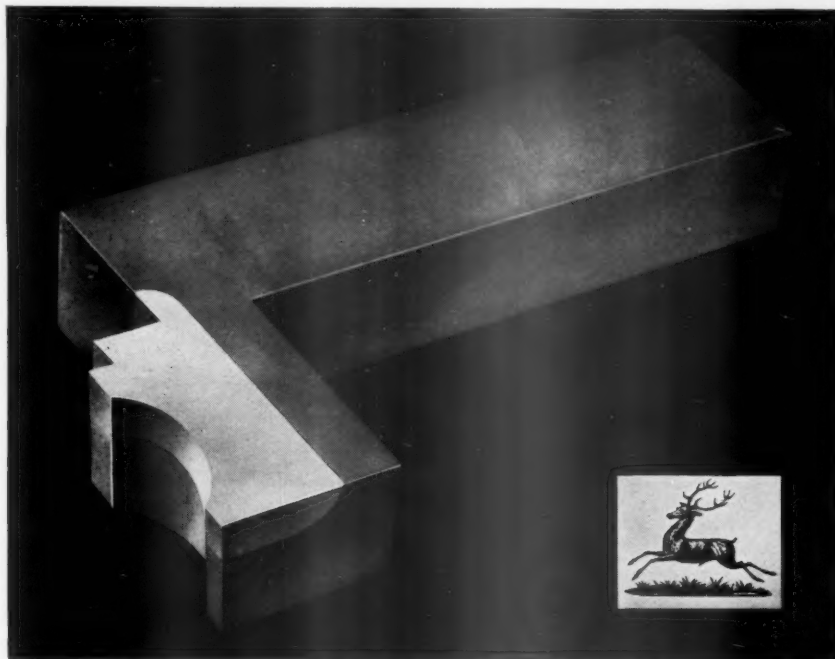
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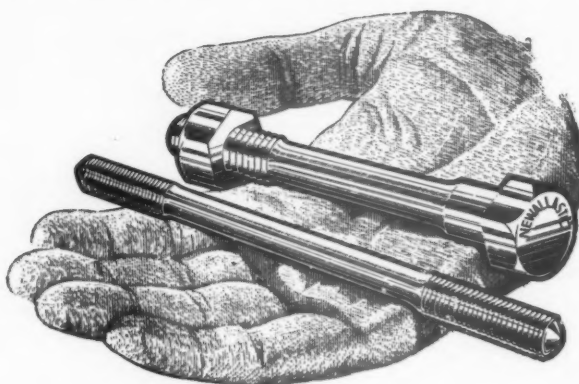
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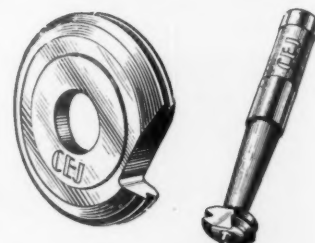
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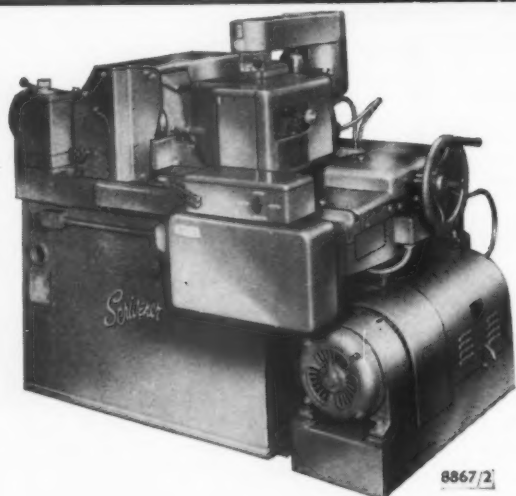
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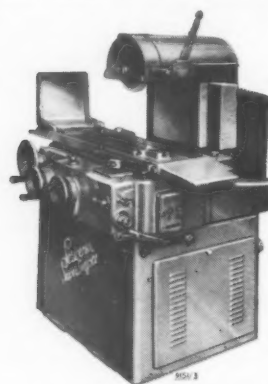
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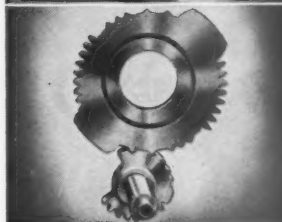
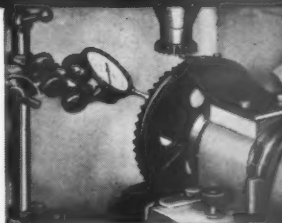
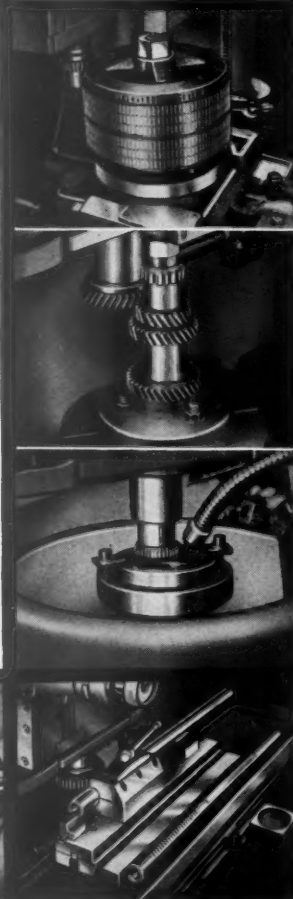


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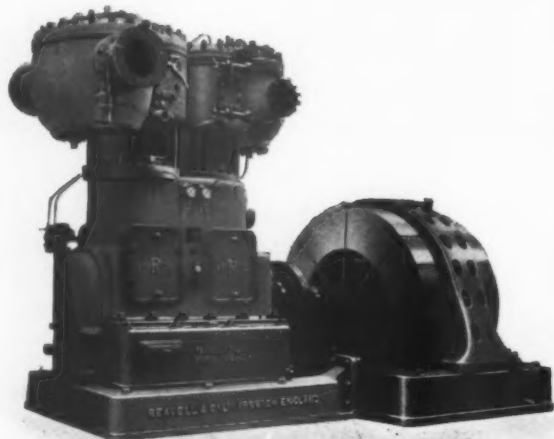
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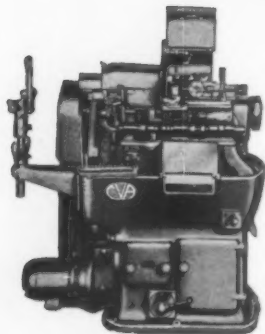
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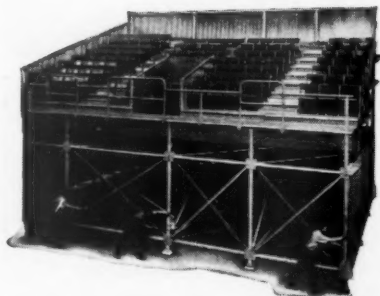
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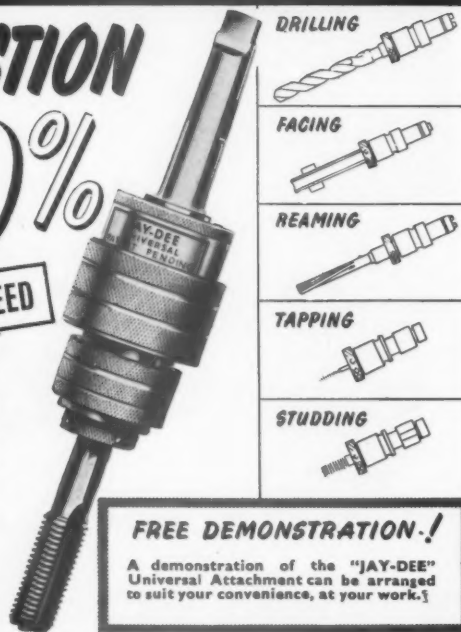
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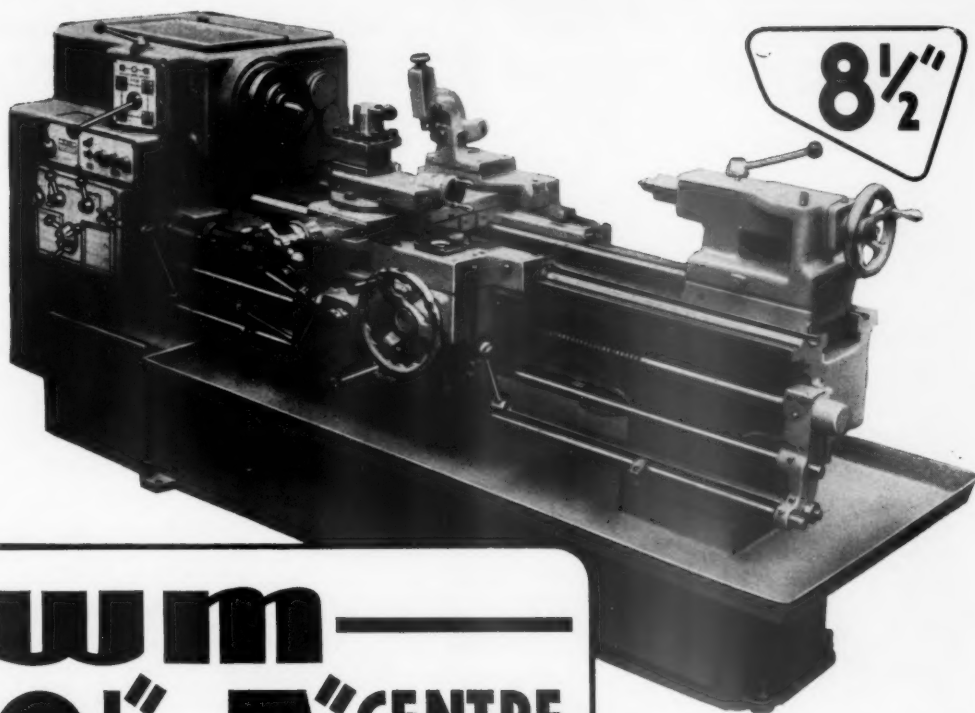
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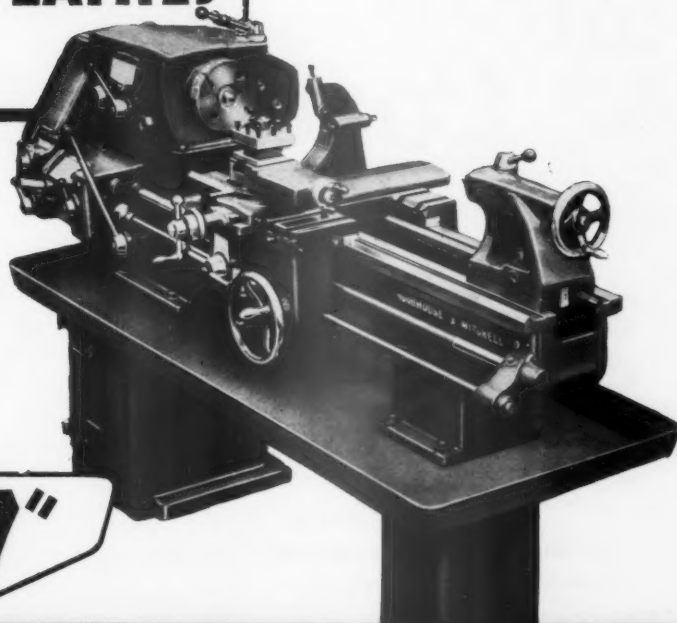
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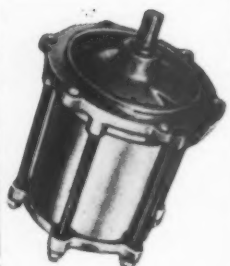
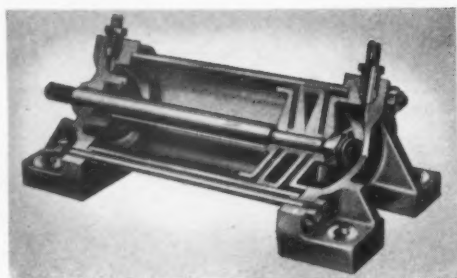
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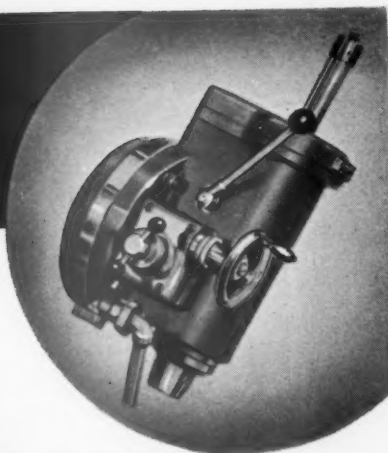
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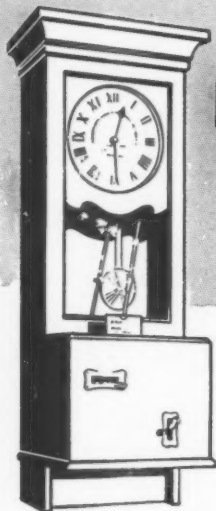
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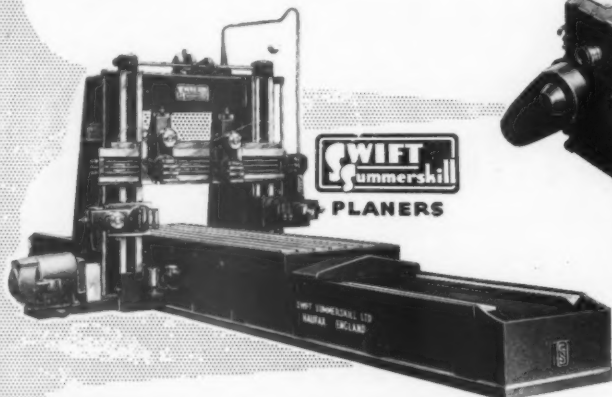
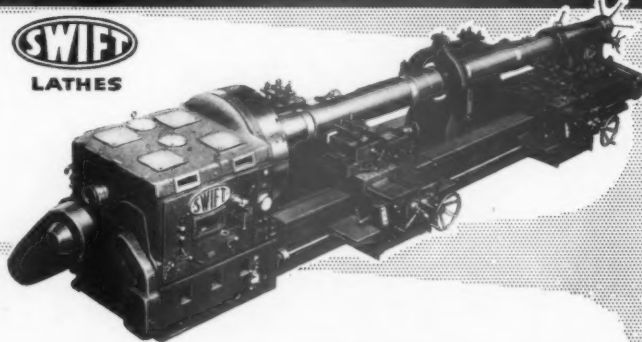
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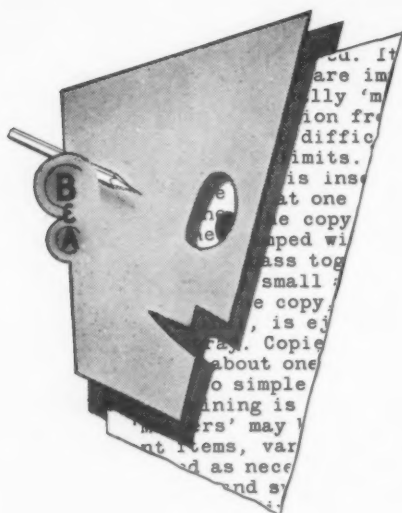
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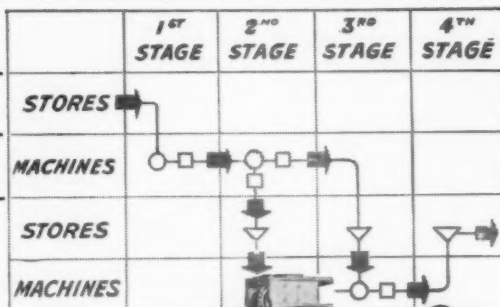
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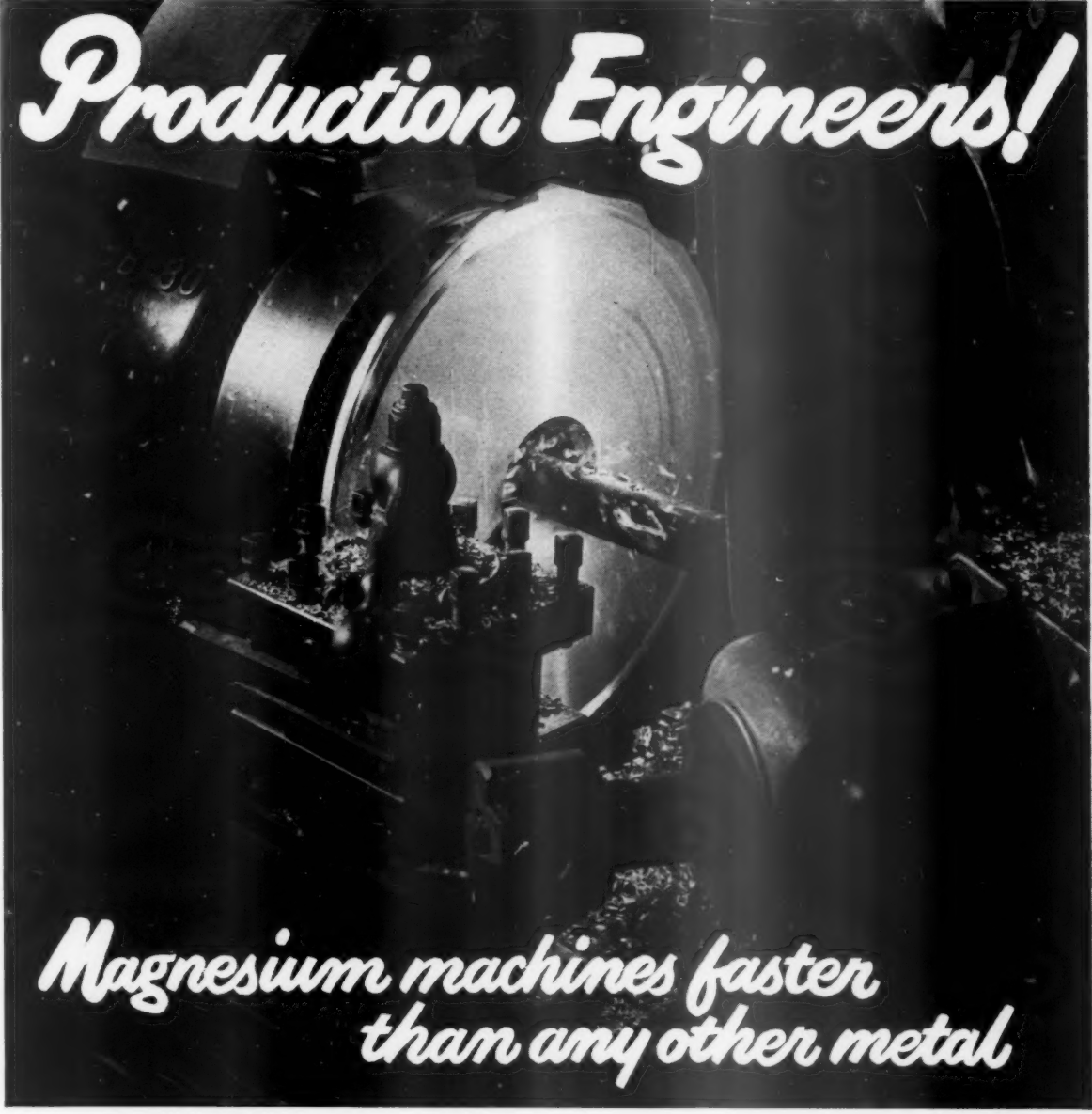
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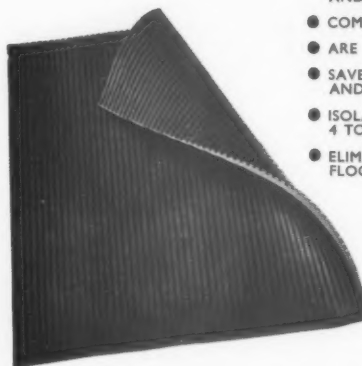
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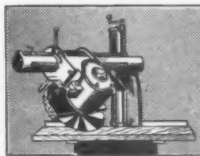
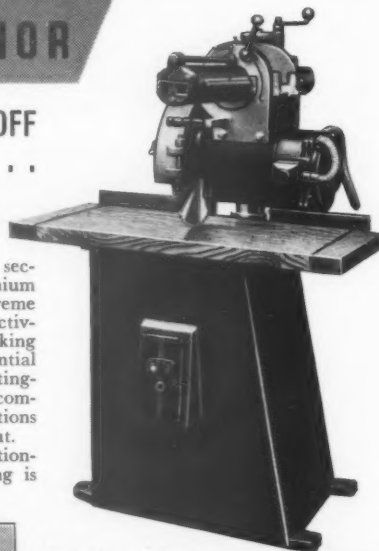
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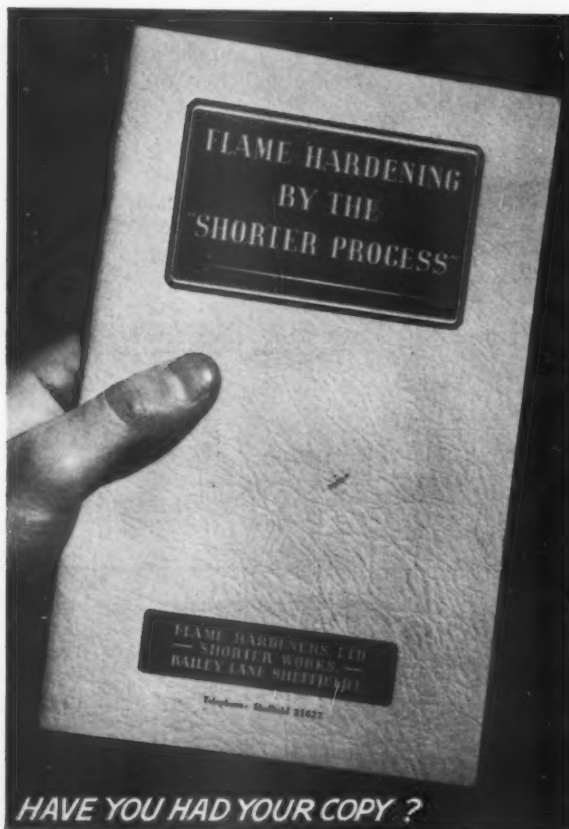


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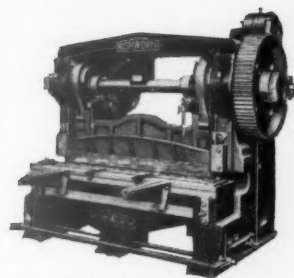
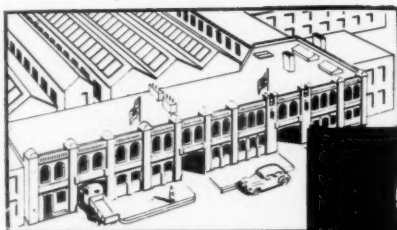
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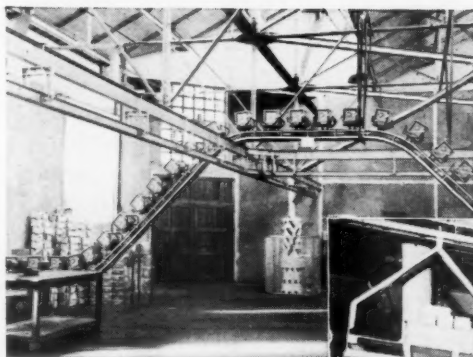


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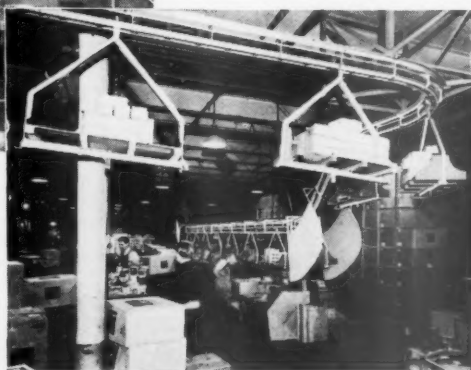
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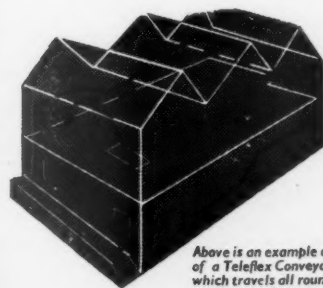


Above: The Teleflex dual-directional chain conveyor adapted to carry tins of biscuits.



Right: Overhead chain conveyor carrying cigarettes in packing and despatch departments at the factory of Messrs. W. A. & A. C. Churchman.

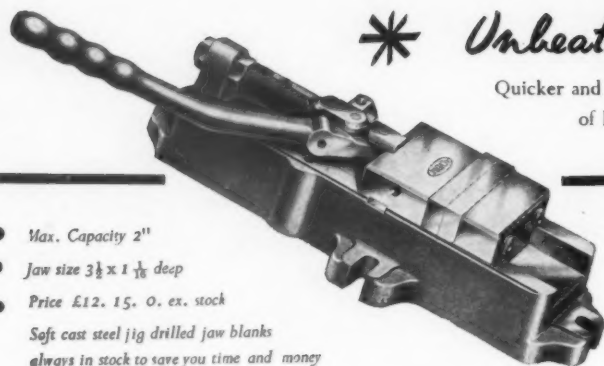
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